NOVEMBER 1982

MDC H0145

SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS

Midterm Main Briefing
16 November 1982

COPY NO 9

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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SPACE STATION NEEDS, ATTRIBUTES AND ARCHITECTURAL OPTIONS

Midterm Main Briefing
16 November 1982

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MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH
5301 Bolsa Avenue, Huntington Beach, California 92647 (714) 896-3311

SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS STUDY NASA HEADQUARTERS

Midterm Review

16 November 1982

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MDAC SPACE STATION MIDTERM BRIEFING
AGENDA

- Summary — Dave Wensley
- Mission Requirements (Task 1)
  - — Methodology - Dave Riel
  - — User Interaction - Dr. Harry Wolbers
  - — Science and Applications Missions - Dr. Harry Wolbers
  - — Commercial Missions
    - Mission Candidates - Dr. Harry Wolbers
    - Electrophoresis - Jim Rose · MDAC · St. Louis
    - Selected Missions - Dr. Myron Weinberg · Booz, Allen & Hamilton
  - — Technology and Operational Missions
  - — National Security Missions (Summary)
  - — Missions Requirements Summary

} Dave Riel

A2

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AGENDA (CONT)

- Programmatics (Task 3) — Bob Cowls
  - — Funding Model
  - — Element Costs
  - — Program Costs
- Mission Implementation (Task 2) — Bill Nelson
  - — Methodology
  - — Architectural Options
  - — Strawman Program
- National Security Missions (DoD Task 4) — Dave Riel (Classified Session)
- Discussion

A3

- **Summary** — Dave Wensley
  - — MDAC Team Organization
  - — Study Approach
  - — Progress Versus Plan
  - — Results to Date
  - — Midterm Conclusions (Trends)

A4

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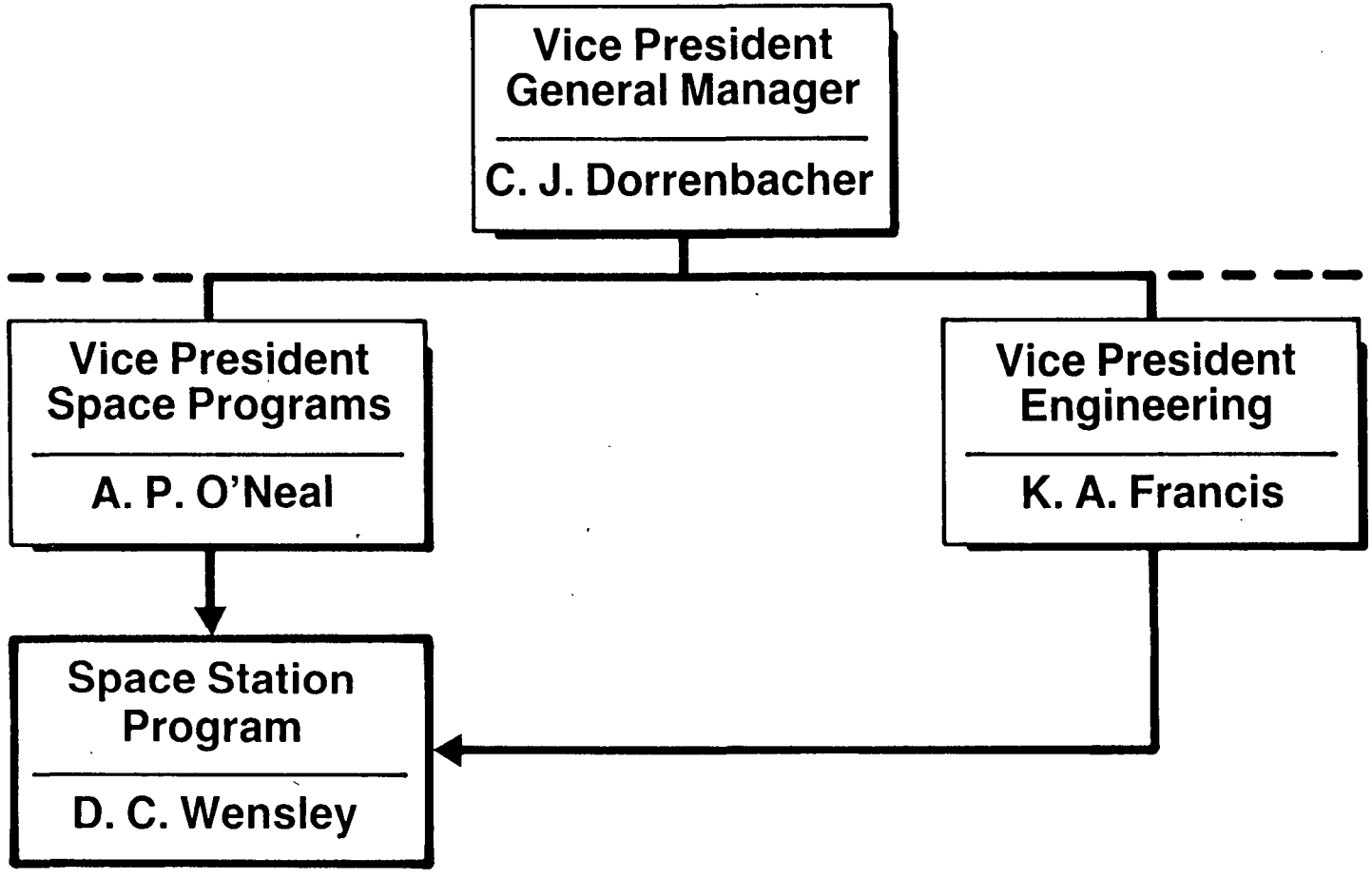
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY HUNTINGTON BEACH



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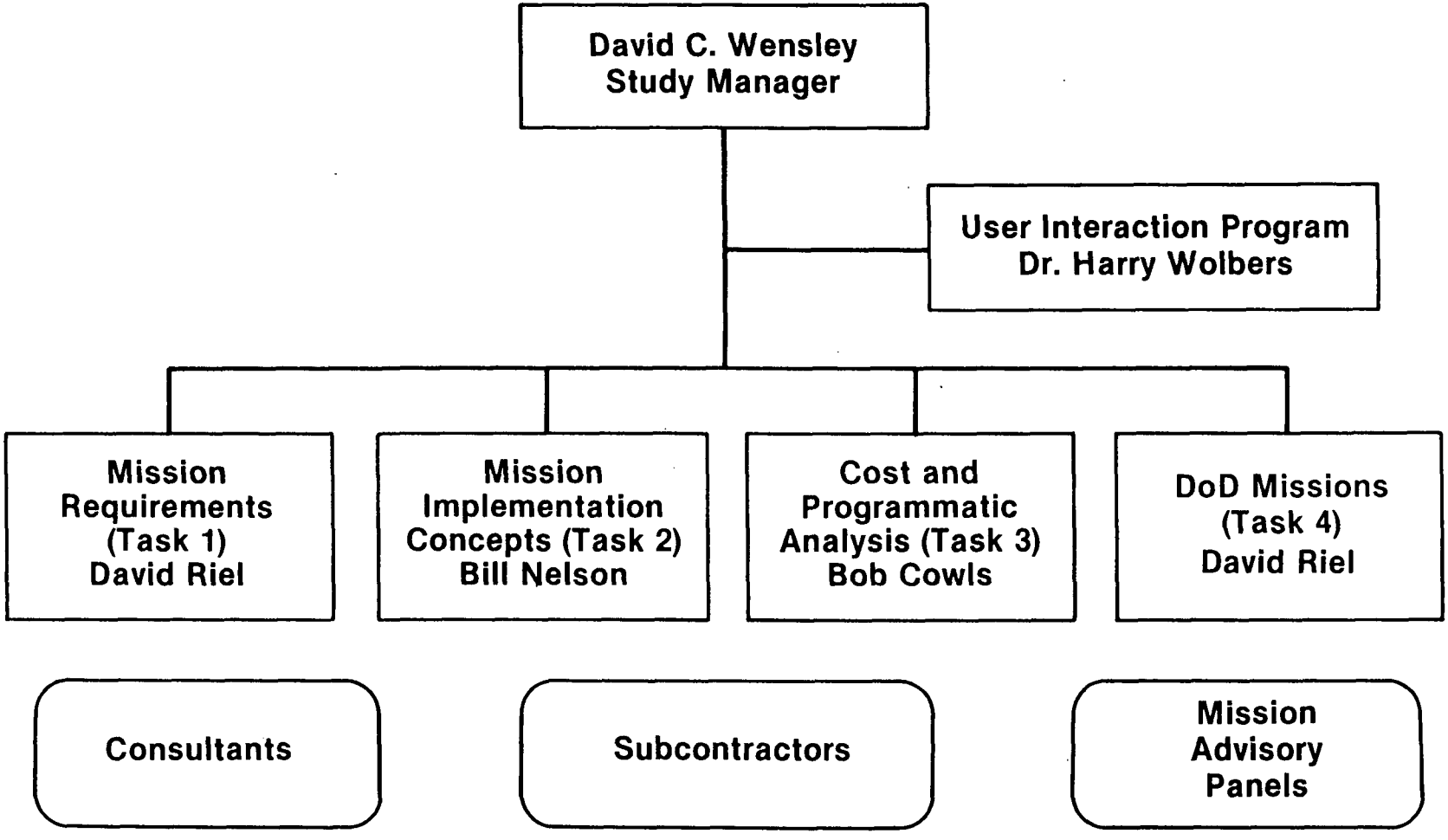
MDAC-HB STUDY ORGANIZATION (U)



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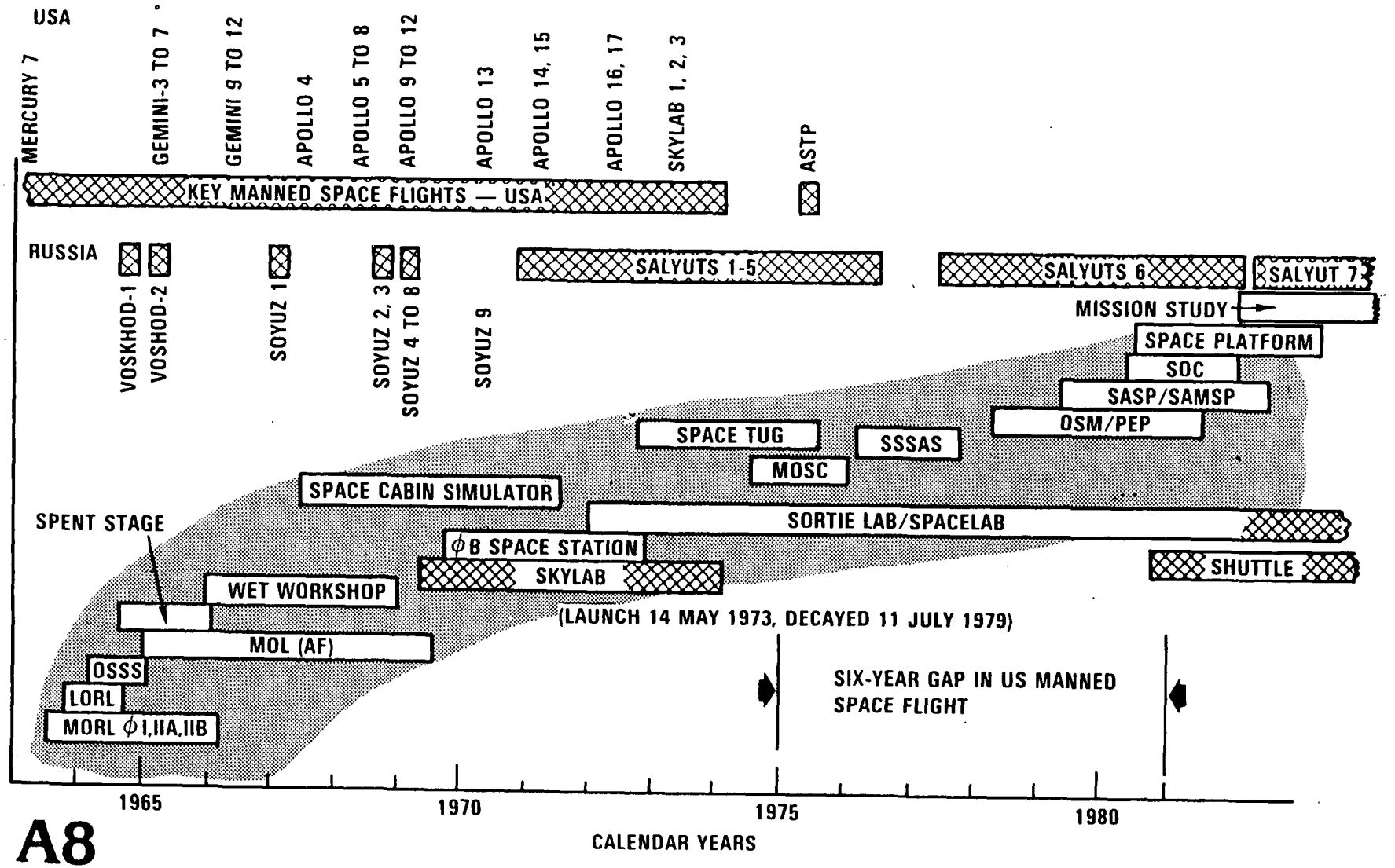
SPACE STATION HERITAGE



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MDAC SUPPORT TEAMS

Consultants

- Booz, Allen & Hamilton
  - — Commercial Missions
  - — Benefits Analysis
- MDAC — St. Louis
  - — Commercial Missions
- Stanford Research Institute
  - — National Defense Missions
- Dr. John Logsdon
  - — Program Planning

Subcontractors

- Ford Aerospace
  - — Communications Missions
  - — Ground Data System
- Hamilton Standard
  - — Environmental Control and Life Support Systems
- Bendix
  - — Navigation and Control
- Vought/LTV
  - — Teleoperators

Mission Advisory Panels

- Science and Applications
- Commercial Missions
- National Security Missions
- Operational Missions
- Technology Missions

A9

MDAC TEAM IS PROMOTING SPACE STATION

- 6 TV Interviews
- 5 Press Conferences and News Releases
- 2 Papers and Publications
- 12 Presentations and Briefings
- 8 Meetings With Private Sector
- 15 Meetings With Government Sector — Political
- 11 Meetings With Foreign Sector

Total: 59 Events to Midterm

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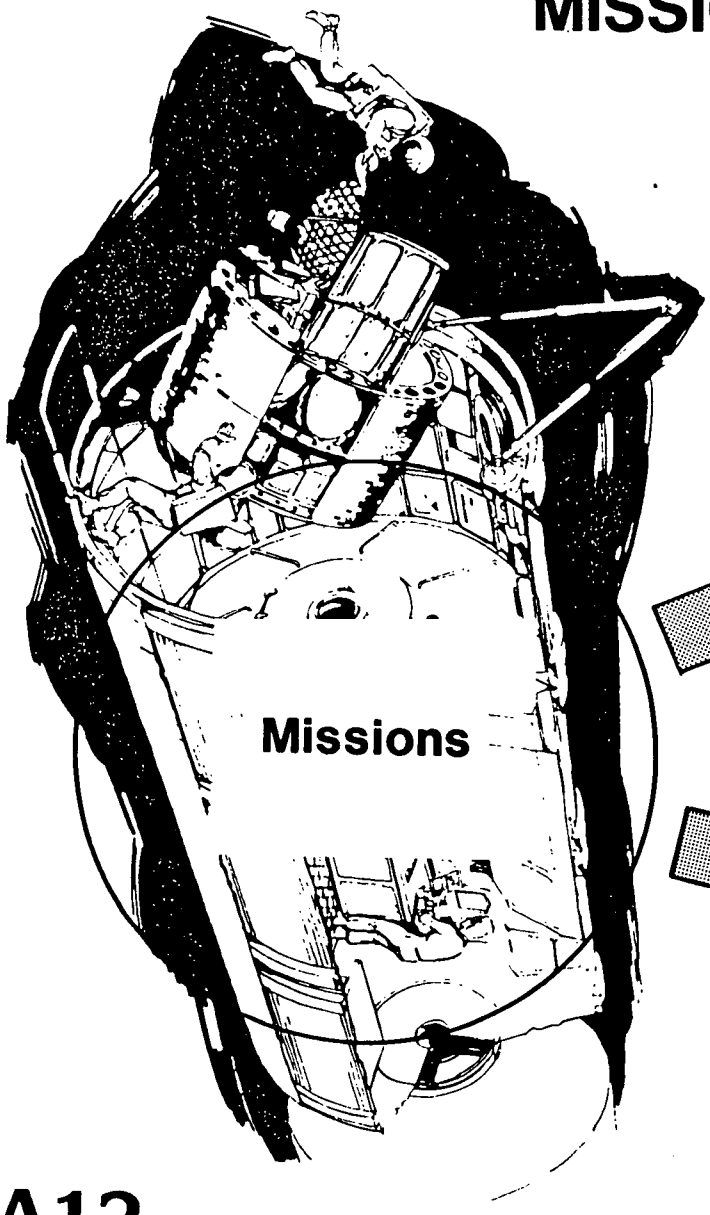
STUDY OBJECTIVES

DEFINE

- The Missions
- Requirements They Impose:
  - For Manned Space Station
  - For Supporting Orbital Facilities
  - For Transportation
- Architectural Solutions:
  - To Implement Above Requirements
- Program Concepts:
  - Content
  - Costs
  - Schedules

A11

MISSION ANALYSIS



Intrinsic

Benefits

Added Value

Requirements

Space Station System

A12

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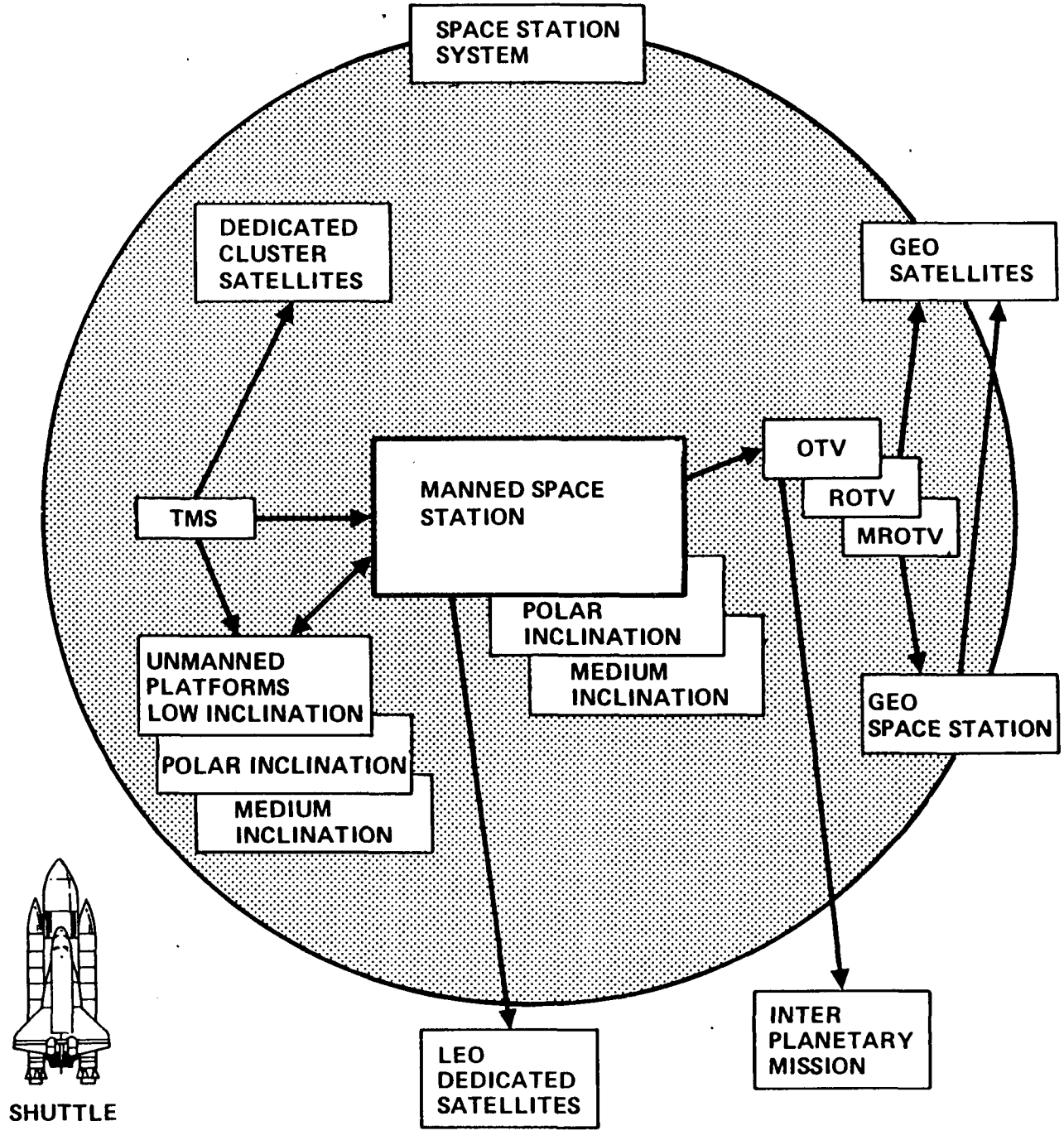
MANNED SPACE STATION — CORE ELEMENT OF THE SPACE STATION SYSTEM



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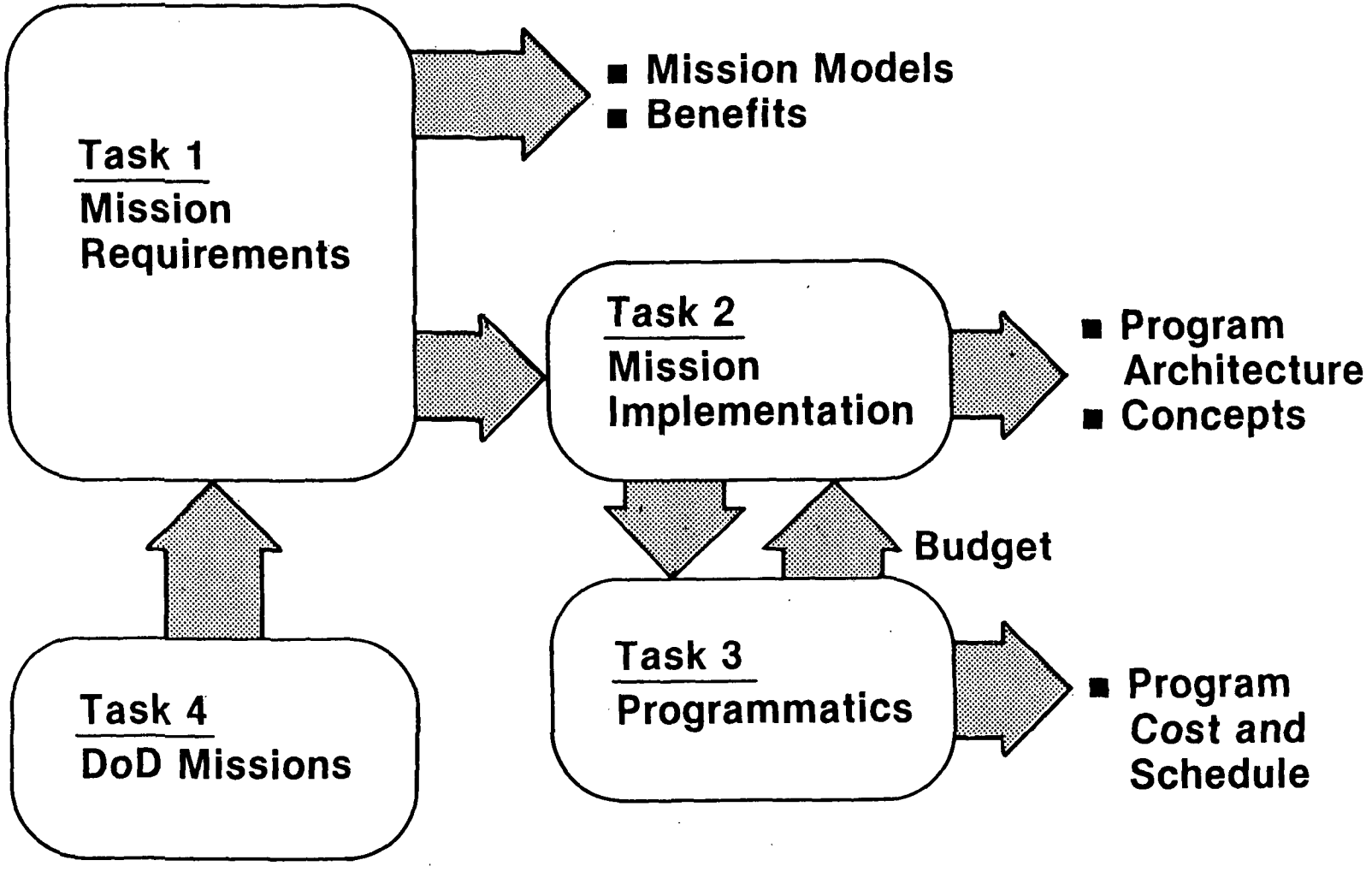
MDAC STUDY APPROACH



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FEATURES OF MDAC STUDY APPROACH

- Complete First Study Cycle by Midterm
- Extensive Use of Background Data Base
- Use of Mission Advisory Panels
- Emphasis on Commercial Missions
- Buffered Access to Key Commercial Users
- Use of "Seed Ideas" to Stimulate New Missions
- Primary Focus on Initial Capability Needs
- Budget Constrained Optimization: "Build-To-Budget"
  - Missions
  - Concepts
  - Programs

A15

MDAC PROGRESS VERSUS PLAN — MIDTERM

VFX843

- User Interaction Plan Implemented
- User Orientation Briefing Package Completed
- 63 User Contacts Completed
- 365 Missions Defined; 95 Selected
- Computerized Mission Data Base Is Operating
- Budget Alternatives Are Defined
- Cost Models Are Defined
- System Costing Model Is Operating
- Architectural Options Are Defined
- Strawman Program Is Selected

A16

First Study Cycle Complete As Planned

RESULTS SUMMARY — MISSIONS

Mission Categories	Identified Missions	Mid-Term Selections	Architecture and Concept Drivers
1. Science/ Applications	137	40	Orbit Location, Stability, Field of View, Contamination Control
2. Commercial	61	12	High Power, Proprietary Control, Man
3. National Security	65	6	Secure Operations, Endurance/Survivability, Hardening
4. Operational Support	25	25	Teleoperators, Manipulators, Depot Services, Man
5. Technology Development	77	12	Exterior OPS (EVA), Man, Hazard Control
Totals	365	95	

A17

BENEFITS OF MAN IN ORBIT

Functions → **Scientist/Observer**

Typical Tasks →

- Real-Time Data Analysis
- Multiple Sensor Use
- Sensor Mode/Parameter Selection
- Cooperation With Principal Investigator
- Target Selection

Development Engineer

- Sensor Operation
- Sensor Evaluation
- Component Testing

Technical Operations Specialist

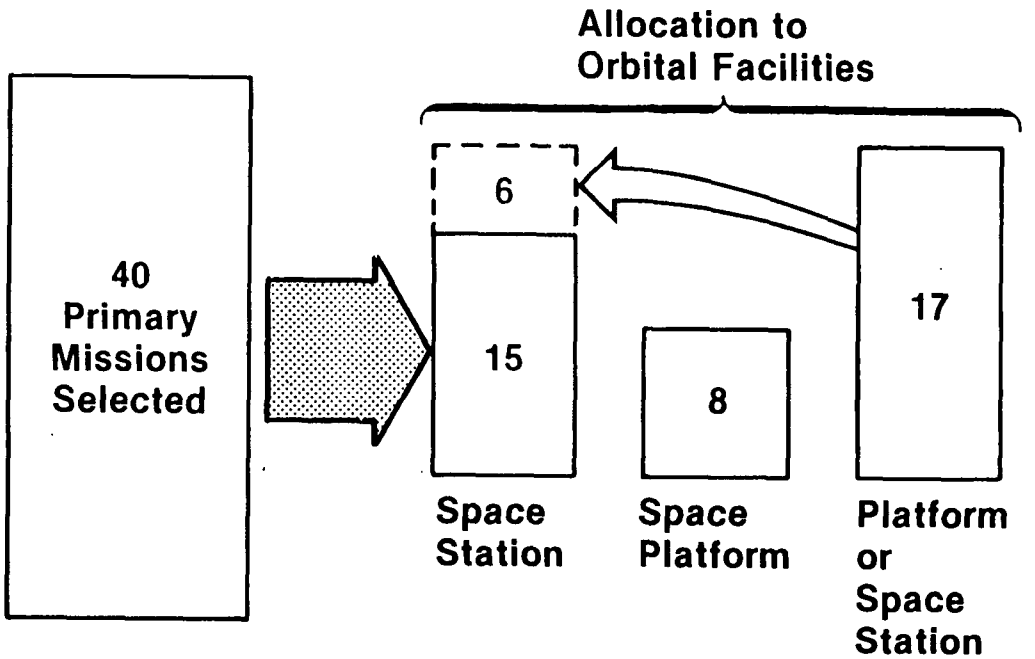
- Equipment Setup, Checkout, Maintenance, Calibration
- Servicing of Sensor and Equipment Consumables

A18

SCIENCE AND APPLICATION MISSIONS

Categories

- Astrophysics
- Communication
- Earth and Planetary Exploration
- Life Sciences
- Materials Processing



Results:

- 15 Missions Require Manned Station
  6 Others Will Benefit Significantly

A19

REQUIREMENTS DEFINITION - ASTROPHYSICS (TYPICAL)

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARCMIN)	STABILITY ARCSEC/ TIME	DATA RATE (MBPS)
SOT	8,200	400	57	6.8	0.9	0.025	0.017/90	0.1/15	50
SIRTF		400		1.3		0.125		2/20	
STARLAB		400		2.2		0.8		10/30	
SCRN		400		0.8		70		N/A	
SOLAR SOFT X-RAY TELESCOPE	1,300	430	57	0.2	0.2			0.1	
STO	16,60		57				8–12		
PINHOLE X-RAY CAMERA	10,00		97						
X-RAY OBSERVATORY	3,600	400	28.5	0.9	0.9		1.0		
HRS	1,800	400	< 45	0.5	0.5	10	6/90	36/0.02	0.03
XTE	1,000	400	28.5	0.6	0.6				
AXAF	10 TO 12,000	500	28.5	2.0	2.0		30	1.0	
LAMAR	9,500	400	28	3.4	0.4	1	3/67	10/0.02	0.1
VLBI	1,400	400	57	0.9	0.9	0.1	2.5/45	150/60	12
ASO	12,500	400	57	4.1		0.025	0.17/90	0.1/15	42

Mass (kg)

Inclination (deg)

Heat Rejection (kW)

Pointing (arcmin)

Data (mbps)

Altitude (km)

Power (kW)

Field of View (deg)

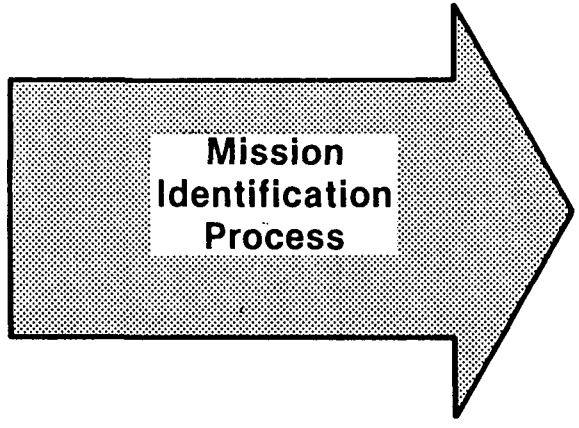
Stability sec/Time

A20

COMMERCIAL MISSIONS

Key Characteristics

- High Market Value
- High Value per Pound
- Not Labor Intensive
- Uses Unique Properties of Space



Results to Date

- 59 Products/Processes Identified
- 18 Relationships Established With Commercial Users:
  - 8 Booz, Allen
  - 10 MDAC
- 25 In-Depth Interviews Completed:
  - 15 Booz, Allen
  - 10 MDAC
- 12 Potential Commercial Missions Identified

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COMMERCIAL MISSIONS
(12 Identified to Date)

MDAC Data Bank Identifier		Areas of Responsibility	
		MDAC	BAH
CIR001	Materials Research Facility	●	
CMP001	Electrophoretic Processes	●	
CMP002	Silicon Ribbon Manufacture	●	
CMP003	Crystals/Diffractors		●
CMP004	Melting/Refreezing		●
CMP005	Homogeneous Mixtures		●
CMP006	Directional Crystal Growth		●
CMP007	Hot/Cold Processes		●
CMP008	Unidirectional Processes		●
CMP009	Earth Observations		●
CMP010	Materials Production		●
CMP011	Misc Operations		●

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BENEFITS ANALYSIS
ELECTROPHORETIC PROCESSES

VFY232

Human Needs	Product Objective	Current Status
Growth Hormone (850,000)*	Stimulates Juvenile Bone Growth, Promotes Healing of Ulcers	Research Quantities, Low Purity
Beta Cells (3,200,000)	Single Injection Cure for Diabetes	Clinical Quantities, Not Separable
α - Antitrypsin (500,000)*	Limit Emphysema Disease State, Enhance Cancer Chemotherapy	Research Quantities, Low Purity
Epidermal Growth Factor (1,100,000)*	Skin Burn and Wound Healing	Research Quantities Low Purity
Interferon (20,000,000)*	Viral Infection Immunity	Low Yield and Purity
Antihemophilic Factor (15,000)*	Eliminate Immunological Reactions for Hemophilia	Low Purity and Loss of By-Products

*Annual Patient Load — U.S. Market

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MANNED SPACE STATION OPERATIONS

VFY160

Enhances Rate of New Product Additions

- 15 Products in 10 Years With Space Station vs 3 Products With Unmanned Free-flyer
- Product Characterization Time Is Reduced From 1 or 2 Years to a Few Months
- Production Time for Clinical Materials is Reduced From 1 or 2 Years to a Few Months
- Dedicated Facilities and Manned Operation Allows:
  - Multiple Product Evaluation
  - Parallel Operations
  - Quick Turnaround

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COMMERCIAL MISSIONS MID-TERM INDICATIONS

- Electrophoresis Is Highest Confidence COMMERCIAL PRODUCTION Mission Identified to Date
- Major Obstacles to Space Exploitation
  - — Proprietary Issue
  - — Cost
  - — Time Delay
  - — Risk
  - — Unknowns
  - — Attractive Alternatives

  } An Available R&D Space Facility is Best Incentive
- Large Scale Production Will Ultimately Require Independent Facilities, Privately Funded

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CANDIDATE NATIONAL SECURITY MISSIONS

Source \ Mission Area	R&D	Data Fusion Center	Space Command Post	Service and Logistics	Surveillance and Reconnaissance	Weapon Platform
Military Space System Technology Model			1	24		1
Space Policy and Requirements				16		
Space Policy and Advanced Concepts				7	1	
Military Space Station Study	3	1	1	1	1	2
Legacy Missions	3					
New Ideas				2	1	
Total 65	6	1	2	50	3	3

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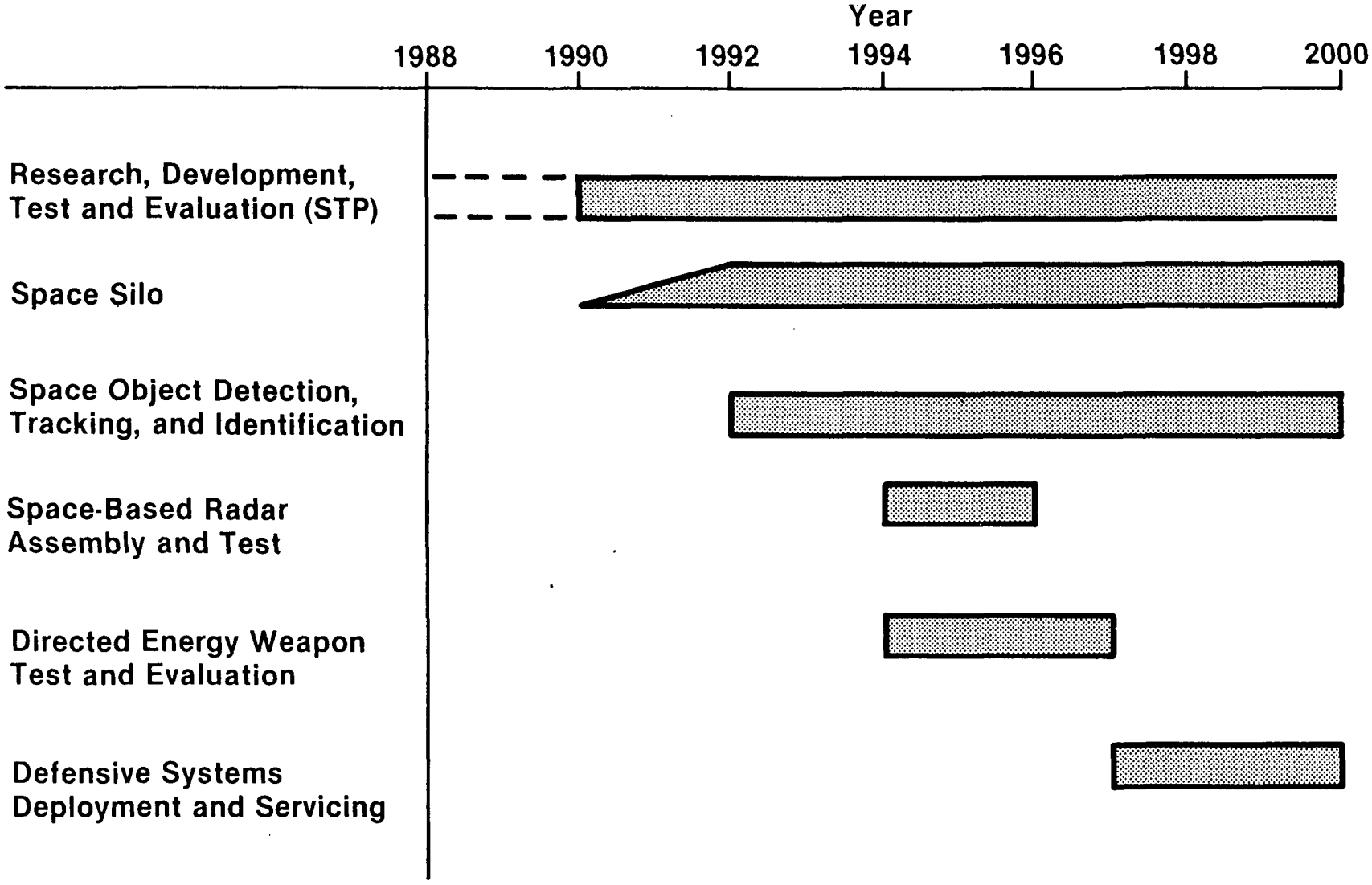
Results to Date

- 65 Candidate Missions Defined
- Most Require Dedicated Satellites
- 6 Are Space Station Candidates

NATIONAL SECURITY MISSIONS
MIDTERM

VFY144



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SPACE OPERATIONS MISSIONS

- Transportation (OTV, TMS, Other)
  - — Deploy/Retrieve
  - — Debris Collection
- Assembly, Integration, Checkout
  - — Large Structures
  - — Stage/Payload Mating
- Service
  - — Maintain/Repair/Replenish
  - — Instrument Reconfiguration
- Storage
  - — Propellants (Cryo, Storables)
  - — Spares
  - — Payloads
- Space Utilization
  - — Quarantine
  - — Rescue

Results to Date

- Teleoperator
  - — Is Required
- Satellite Servicing
  - — Low Cost
  - — High Payoff
- Cryogen Depot
  - — Offers Major Economic Benefit
- Man Participation is Essential

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TECHNOLOGY DEVELOPMENT MISSIONS

- Utilize the Unique Space Station Environment
- Enable:
  - — Advanced Mission Technology
  - — Increased Space Station Capability

  - Advanced Missions
  - More Mission Capacity
- Provide Benefits to All Categories of Users
- Majority Require Manned Participation
- Are Relatively Short Term and Orbit Independent

A29

VFY243

MISSION FOCUS – INITIAL CAPABILITY

Primary Objectives

R&D

- Advance Science
- Push Technology – All Mission Categories
- Enable Commercial Development

Operational

- Logistics Support for Payloads and Assets
- Develop Low-Cost Reusable (Orbital) Transportation
- Limited Commercial Production
- Manned Enhancement
  - All Mission Areas

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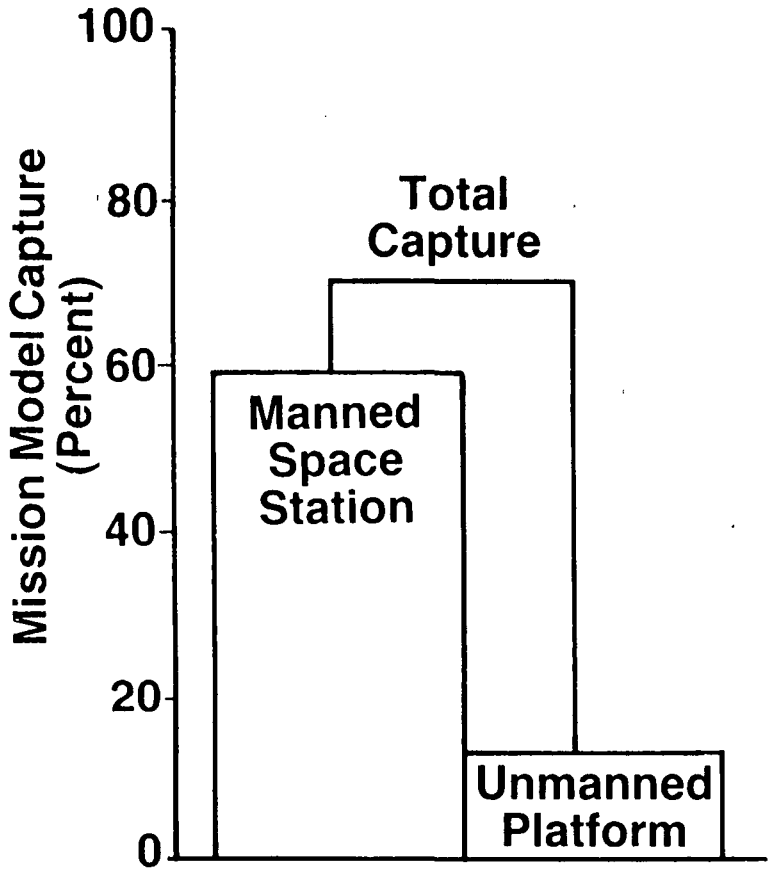
REQUIREMENTS ACCOMMODATION
INITIAL CAPABILITY

VFY242



- Manned Space Station Required
  - Small Crew Size: 4-6
  - Power: 30-40 kW
- Unmanned Platform(s) Desired
  - Man-Accessible
  - Co-Orbiting
  - Power: 20 to 35 kW
- Evolutionary Features
  - Replication for Other Orbits
  - Modular Growth

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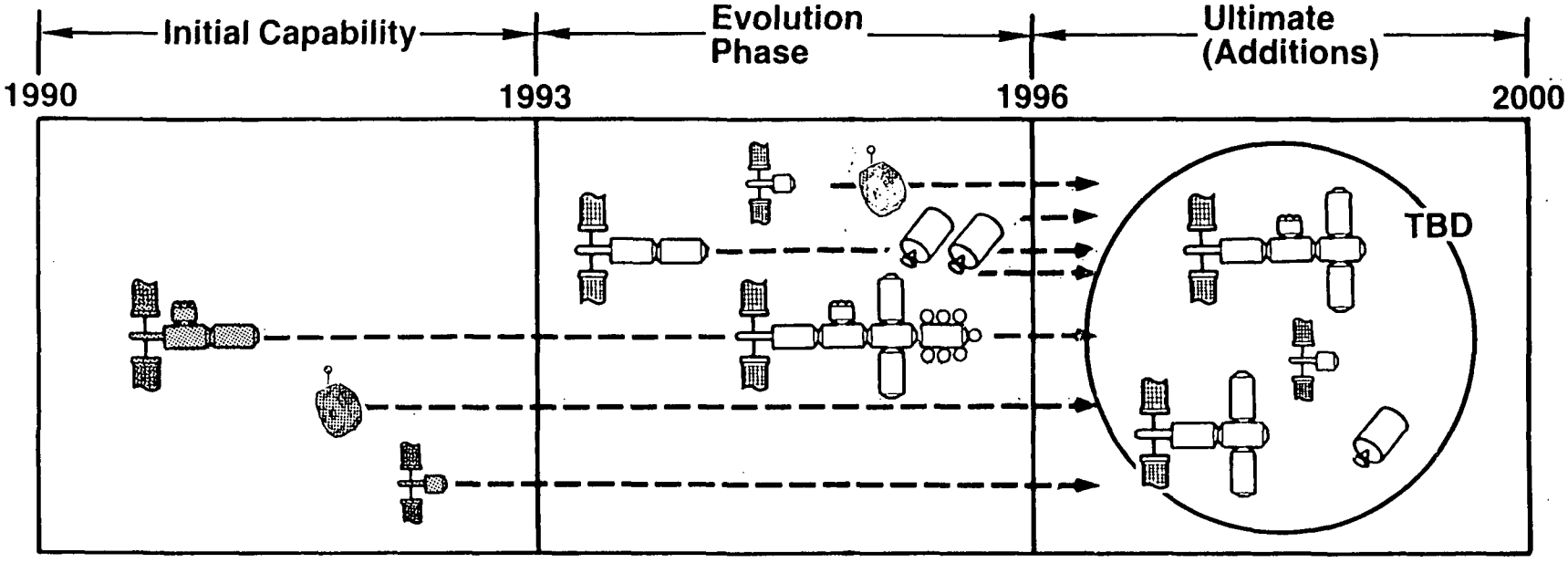
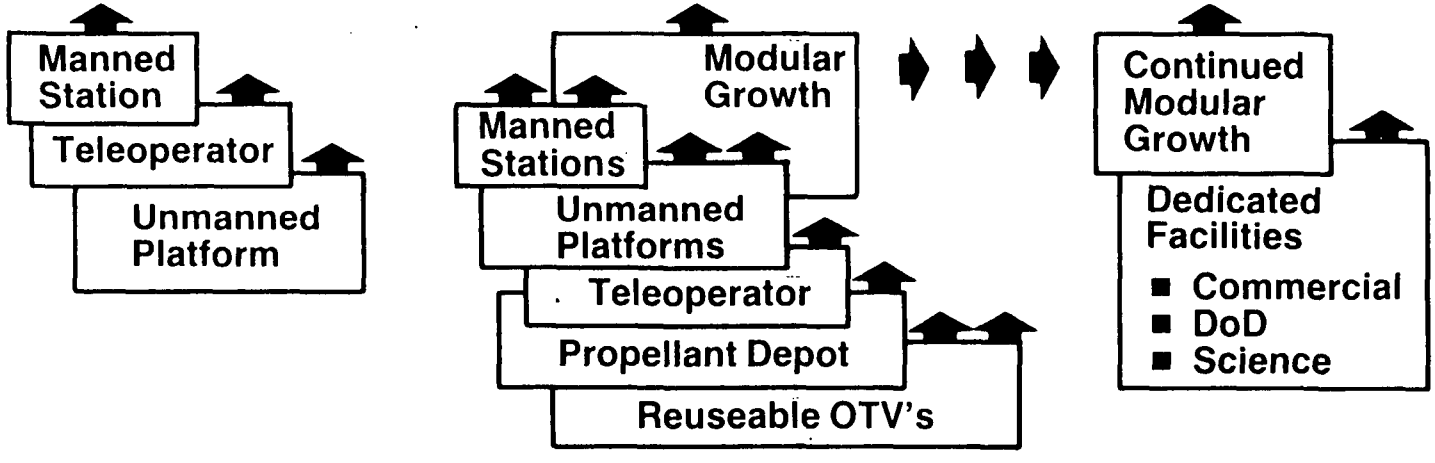
CAPABILITY GROWTH OPTIONS





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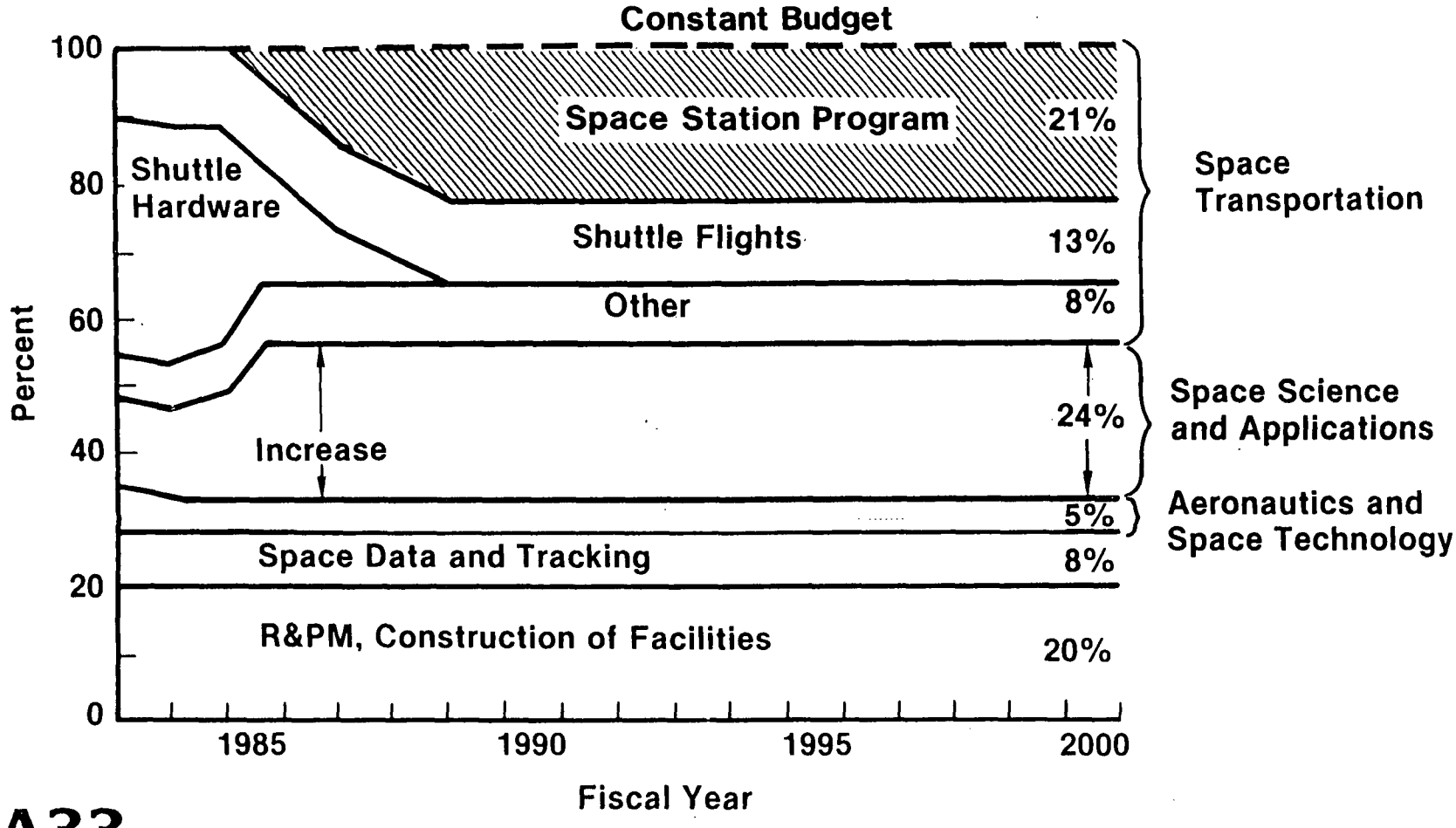
NASA BUDGET ALLOCATION ASSUMPTIONS



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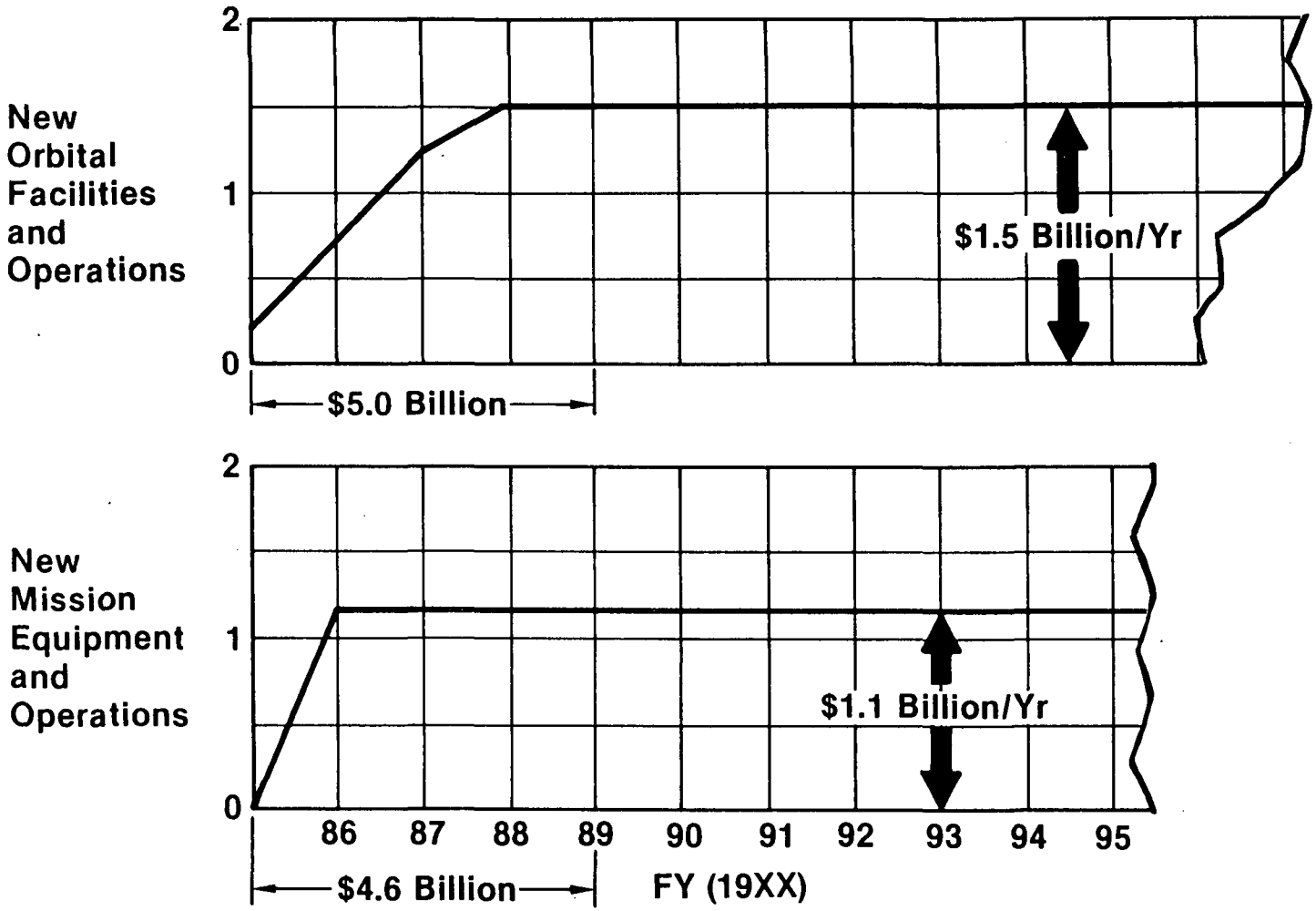
BUDGET MODEL NOMINAL CASE
(Billion Dollars, 1984)



Notes: (1) Science and Applications Budget Increased 60% Above 1983
(2) Shuttle Flights Budgeted at $0.9 Billion/Yr, Are Excluded
(3) All NASA Funds; No Commercial, DoD or Foreign Funds

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SAMPLE PROGRAM COSTS

100% MISSION CAPTURE

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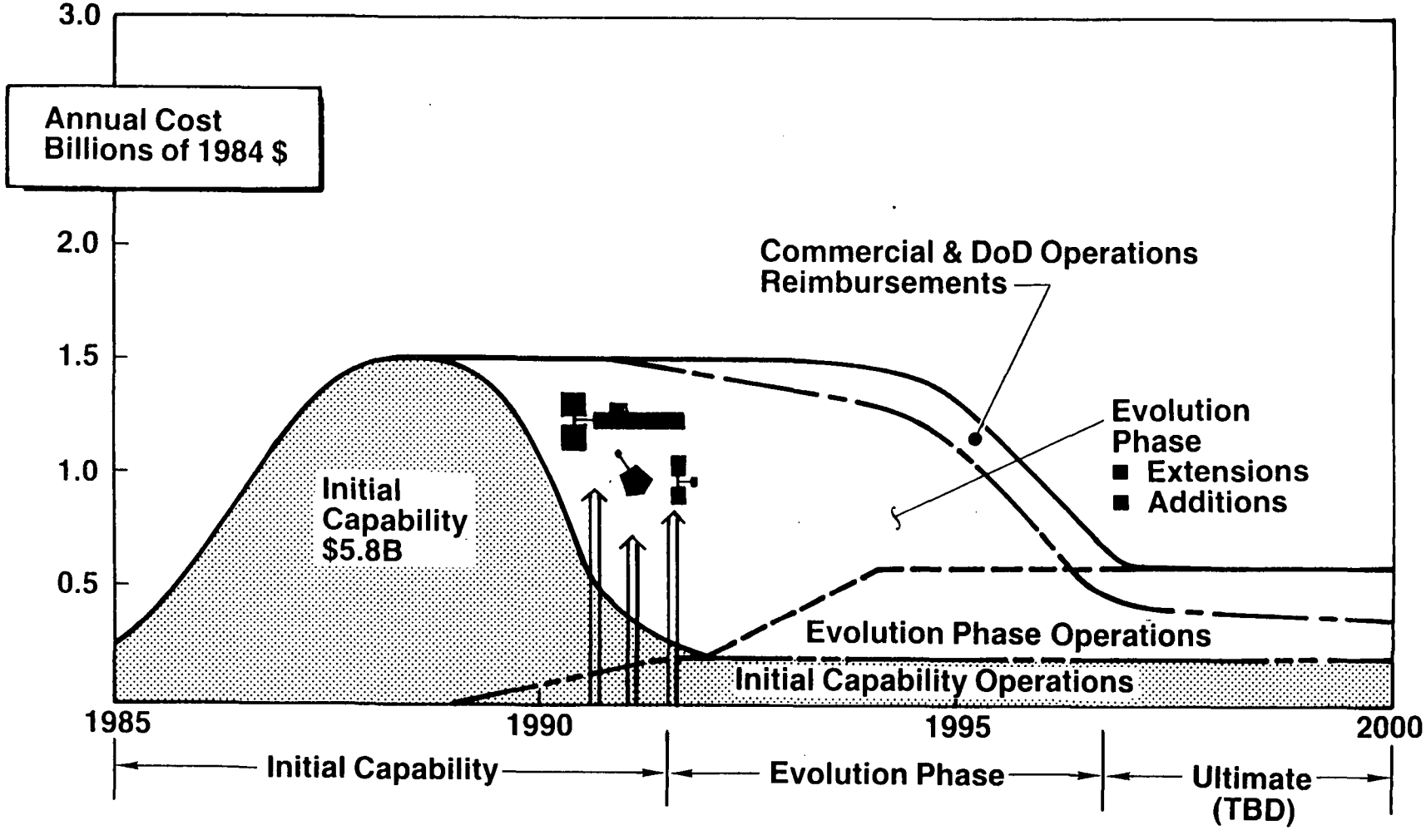

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MID-TERM SUMMARY

Mission Needs

- Mission Opportunities and Benefits Sufficient to Justify Space Station
- Early Needs are R&D and Operations Oriented
- Space Station Availability Will Stimulate Commercial Interest

Space Facilities

- Manned Facility has Highest Mission Capture
- 4-6 Man Crew Indicated
- Unmanned Platforms Highly Desired
- Multiple Orbit Locations Needed

Costs

- Affordable Within Projected NASA Budget

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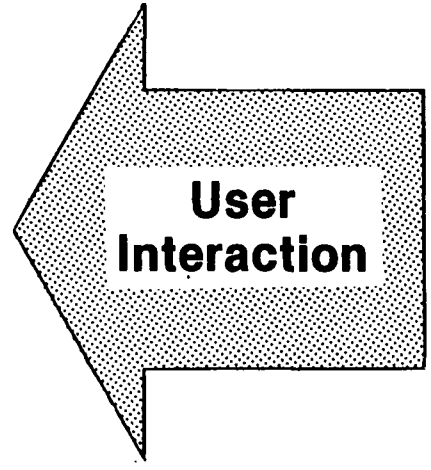
MISSION REQUIREMENTS (TASK 1) METHODOLOGY

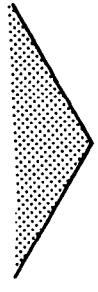
Dave Riel

MISSION REQUIREMENTS

- Define Missions in Each Category
- Assess Benefits
- Validate Requirements and Benefits
- Prioritize Missions



- Derive Space Station System Sizing Requirements
  - — Manned Space Station
  - — Platform
  - — Dedicated Satellites



  - — Orbit Location
  - — Volume
  - — Power
  - — Crew

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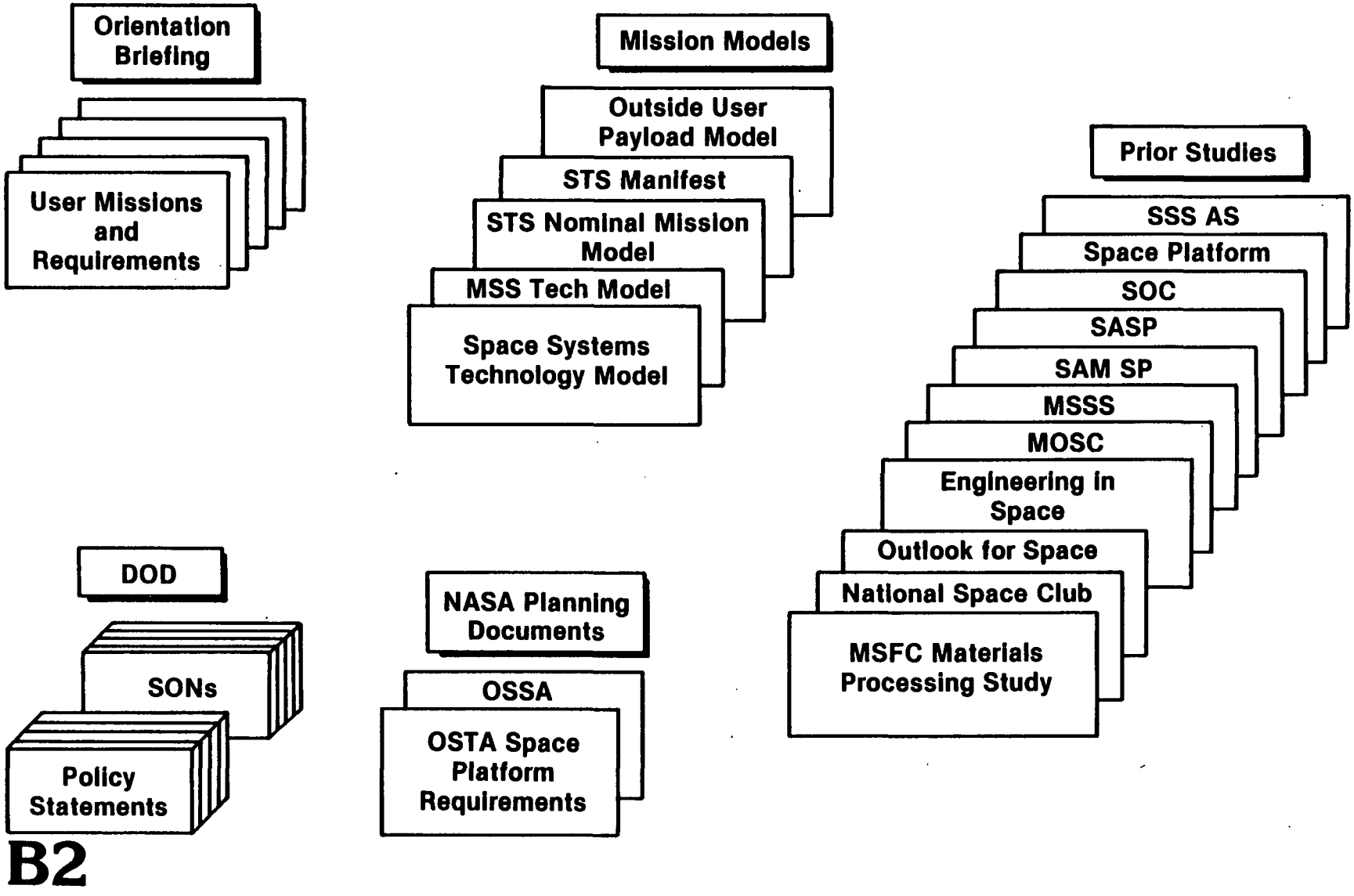
PRIMARY MISSION DATA SOURCES

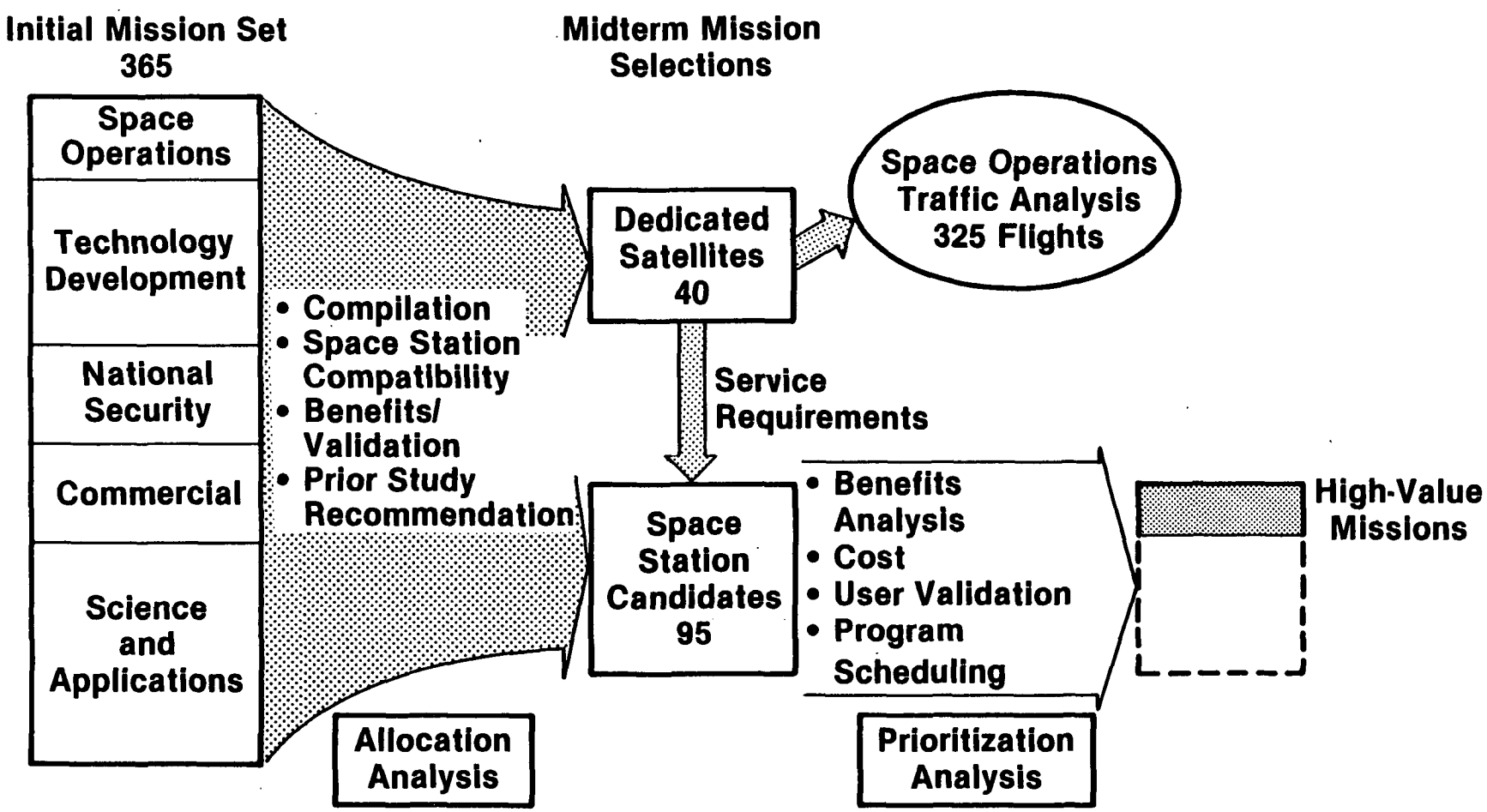


BENEFIT ANALYSIS TECHNIQUES USED

Mission Category	Technique	Data/Value
Science/Applications	Peer Judgment Performance	■ Technology Mission Models ■ NASA Planning Documents ■ Increased Capability
Commercial	Economic Indicators Performance	■ Market Potential ■ Return on Investment ■ Value Added ■ Increased Throughput
National Security	Performance Constituency	■ New Capabilities ■ Augmented Capacity ■ SONs
Technology Development	Performance Peer Judgment	■ Enabling Capability ■ Technology Mission Model ■ OAST Plans ■ Subsystem Test Bed
Space Operations	Performance Cost	■ Increased Delivery ■ Reduced Flights

B3

MISSION SELECTION PROCESS



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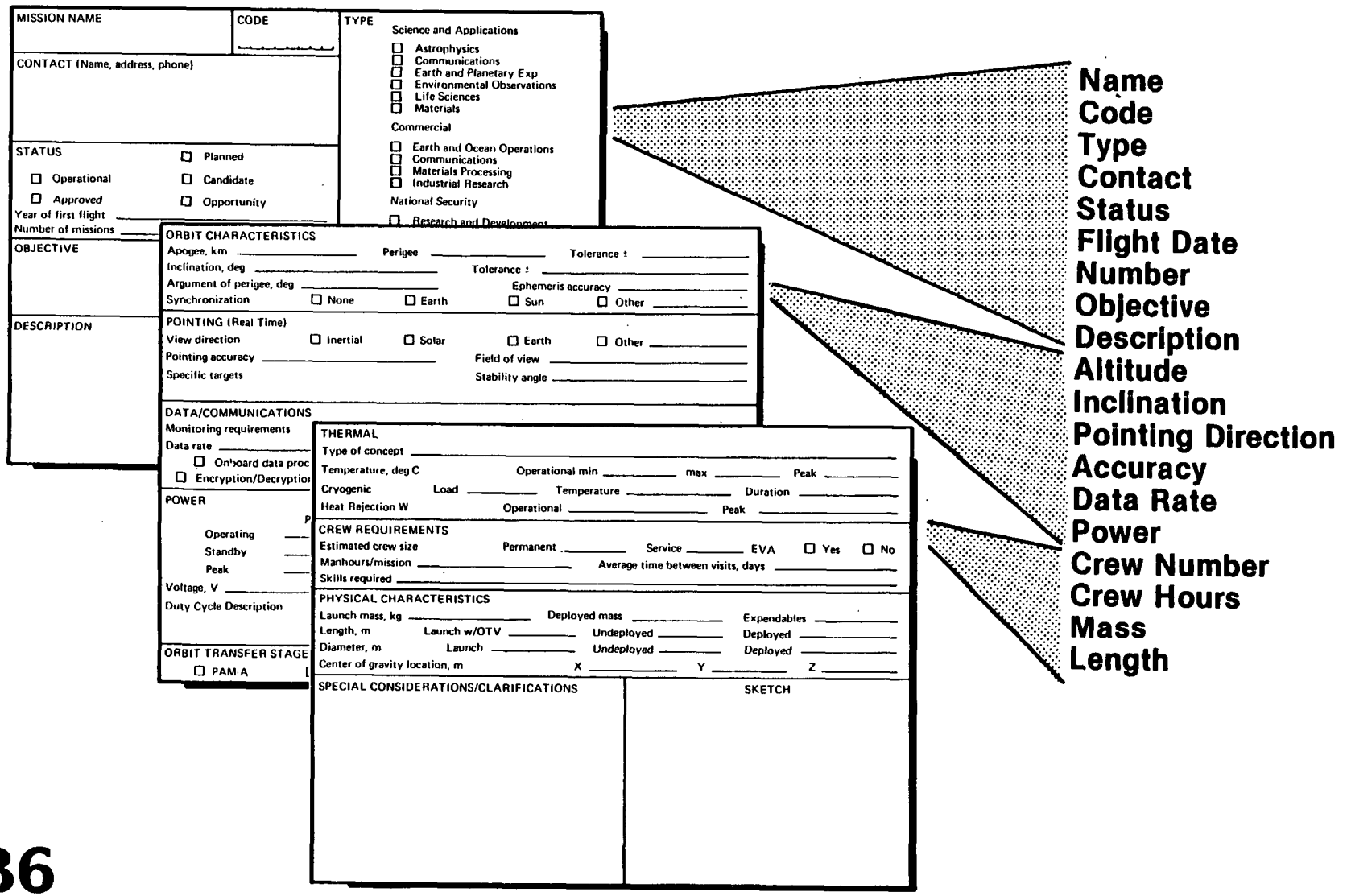
HIGH-VALUE MISSIONS — MIDTERM

Category	Mission Capability	Benefit
■ Science/Applications	■ Solar, Stellar, Earth Orientation Capabilities	■ Increased Performance
■ Commercial	■ Electrophoresis	■ Measured Throughput Increase ■ Investment Commitment
■ National Security	■ RDT&E Mission Capability	■ Allows Development of Needed Systems
■ Technology Development	■ Cryogen Transfer/Storage	■ Enables High-Performance and Cost Saving OTV
■ Space Operations	■ Space Telescope Servicing	■ Reduced Launch Costs

B5

MIDTERM MISSION DEFINITION

95 Mission Defined



B6

MISSION REQUIREMENTS (TASK 1)
USER INTERACTION

Dr. Harry Wolbers

USER INTERACTION

- User Requirements Define the Market for Space Systems
- Our Goal
  - Understand Needs of Potential Users and Encourage Their Utilization of Future Space Systems Where Appropriate
- Our Approach
  - Review of the Literature
  - Review by MDAC Mission Advisory Panels
  - Direct Contact With Representatives of Each Interest Area
- Our Emphasis in Approach Varies With the Maturity/ Heritage of the Area

C1

USER INTERACTION PLAN

AREA	STATUS	PURPOSE OF USER CONTACT
Science and Applications	■ Requirements Well Documented ■ Benefit of Prior Studies and Continuing Peer Reviews	■ Validate Our Understanding of Current Plans
Commercial	■ Emerging Area ■ Little Hard Documentation	■ Continuing Contacts Needed to Stimulate New Insights
National Security	■ Requirements Documented but Facilities Not Defined	■ Validate Our Understanding of Needs and Offer Ideas
Operations and Space Technology	■ Previous Studies and Documentation Provide Point of Departure ■ New Requirements Emerge As Systems Are Defined	■ Validate Our Understanding of Current Requirements and Offer Ideas

C2

USER CONTACTS TO DATE

MISSION AREAS	INTERVIEWS
Science and Applications	5*
— (MDAC Science Advisory Panel)	
Commercial	25
— (15 Booz-Allen, 10 MDAC)	
National Security	16
— (DoD Space Division Headquarters, Los Alamos)	
Operations and Space Technology	17
— (MSFC, JSC, JPL, MDTSCO and 6 Aerospace Contractors)	
Total to Date	**63**

*Contacts Limited to MDAC Advisory Panels Pending Review With NASA Space Station Task Force Science and Application Mission Panel

C3

MISSION REQUIREMENTS (TASK 1)
SCIENCE AND APPLICATIONS MISSIONS

Dr. Harry Wolbers

SCIENCE AND APPLICATIONS MISSION PLANS

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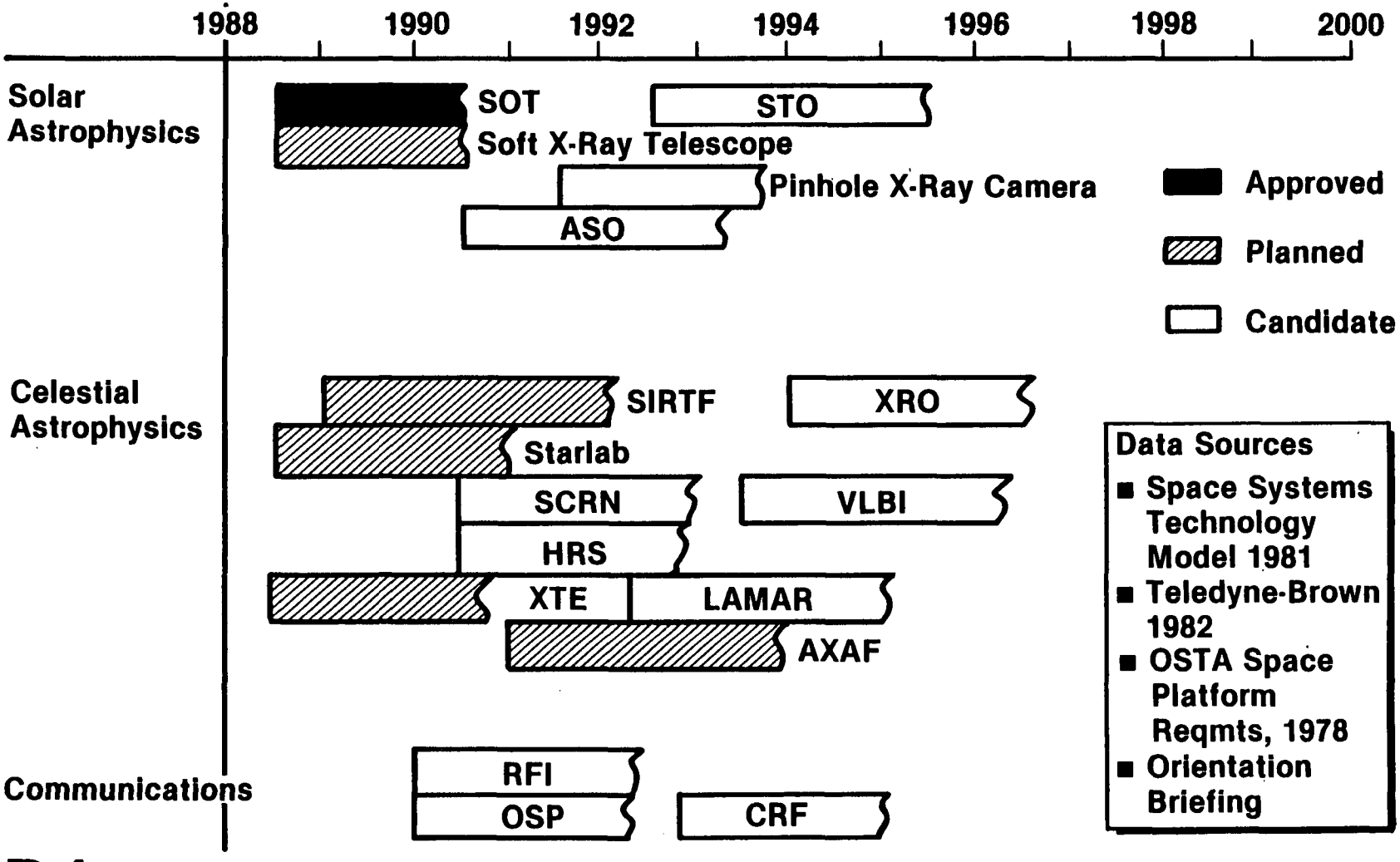
SELECTION BASED ON PEER JUDGMENT



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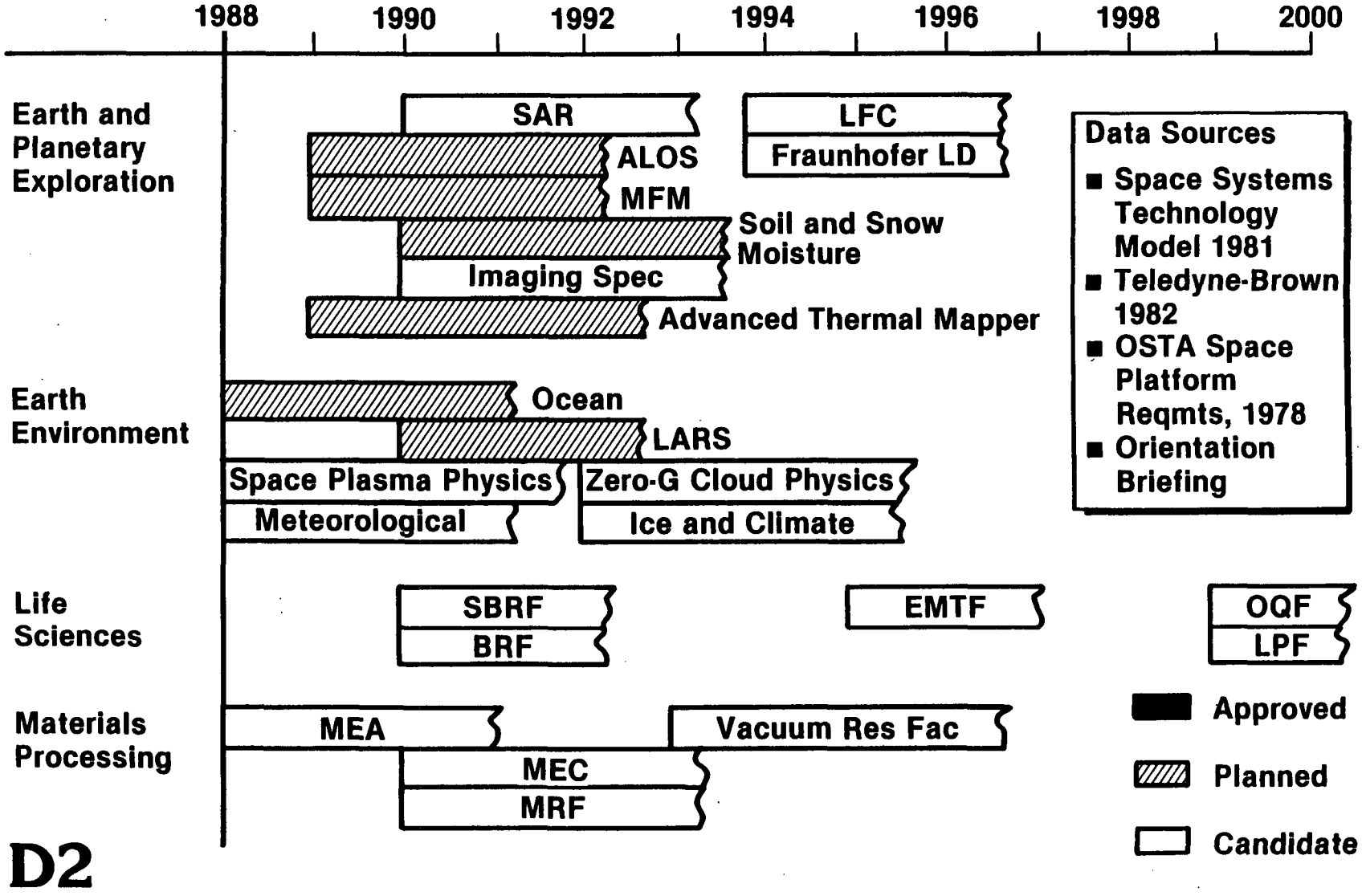
SCIENCE AND APPLICATIONS MISSION PLANS

VFX891

SELECTION BASED ON PEER JUDGMENT



D2

SCIENCE AND APPLICATIONS MISSIONS

- Astrophysics
- Communications
- Earth and Planetary Exploration
- Environmental Observations
- Life Sciences
- Materials Processing

ASTROPHYSICS PAYLOADS

OBJECTIVES

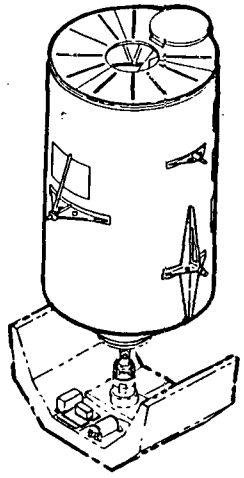
- Investigate Properties of Extragalactic Space, the Milky Way Galaxy, and the Solar System
- Address the Key Questions of Cosmic Evolution

KEY MISSION DRIVERS

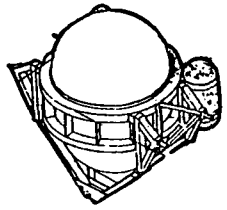
- Precise Pointing and Stability Requirements (SIRTF, STARLAB, SOT, ASO)
- Hot Object Avoidance Zones for Celestial Instruments
  - — 90° Zone Around Sun (SIRTF, LAMAR)
  - — 60° Zone From LOS (SIRTF)
- High Slew Rates (> 40°/Min) (SIRTF, STARLAB)
- High Data Rates (SOT, ASO, VLBI)
- Focal Plane Instruments Susceptible to Radiation (SIRTF, STARLAB)
- Optical Instruments Sensitive to Contaminants/ Condensation
- Some Instruments Vent He, Xe, CH_4 (SCRN, LAMAR)

D3

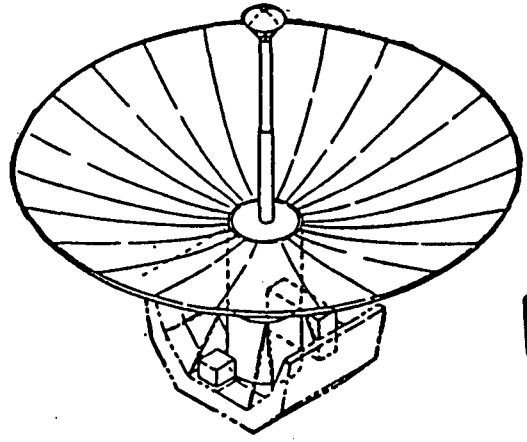
ASTROPHYSICS INSTRUMENTS/FACILITIES



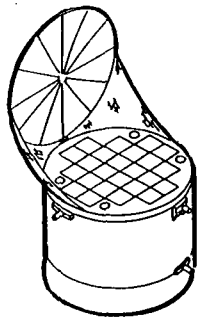
Solar Optical Telescope (SOT)



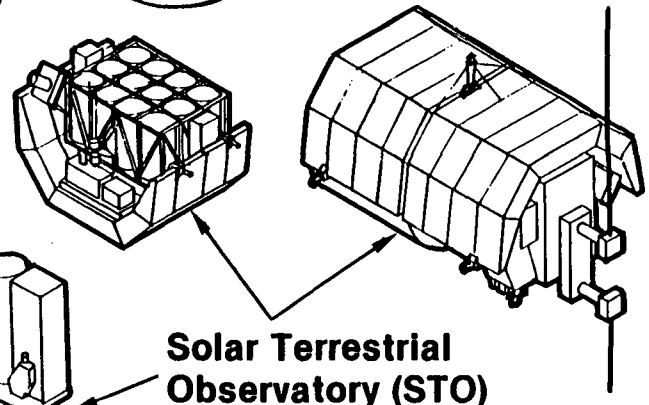
Spectra of Cosmic Ray Nuclei (SCRN)



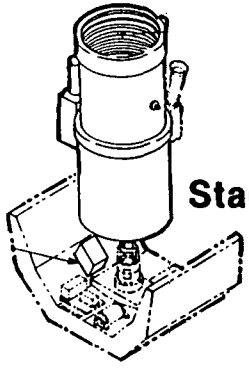
Very Long Baseline Interferometery (VLBI)



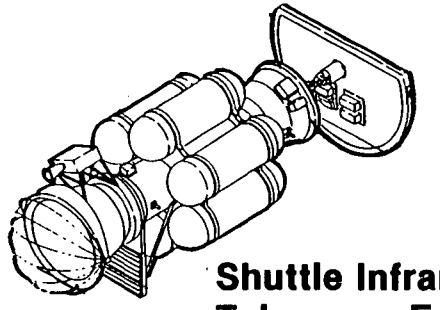
Large Area Modular Array of Reflectors (LAMAR)



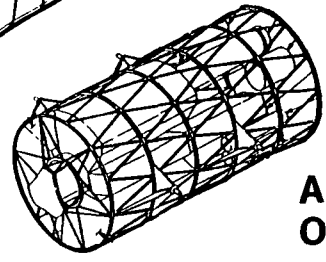
Solar Terrestrial Observatory (STO)



Starlab



Shuttle Infrared Telescope Facility (SIRTF)



Advanced Solar Observatory (ASO)

D4

CHARACTERISTICS OF ASTROPHYSICS INSTRUMENTS/FACILITIES

VFY078

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARCMIN)	STABILITY ARCSEC/ TIME	DATA RATE (MBPS)
SOT	8,200	400	57	6.8	0.9	0.025	0.017/90	0.1/15	50
SIRTF		400		1.3		0.125		2/20	
STARLAB		400		2.2		0.8		10/30	
SCRN		400		0.8		70		N/A	
SOLAR SOFT X-RAY TELESCOPE	1,300	430	57	0.2	0.2			0.1	
STO	16,60		57				8–12		
PINHOLE X-RAY CAMERA	10,00		97						
X-RAY OBSERVATORY	3,600	400	28.5	0.9	0.9		1.0		
HRS	1,800	400	< 45	0.5	0.5	10	6/90	36/0.02	0.03
XTE	1,000	400	28.5	0.6	0.6				
AXAF	10 TO 12,000	500	28.5	2.0	2.0		30	1.0	
LAMAR	9,500	400	28	3.4	0.4	1	3/67	10/0.02	0.1
VLBI	1,400	400	57	0.9	0.9	0.1	2.5/45	150/60	12
ASO	12,500	400	57	4.1		0.025	0.17/90	0.1/15	42

Mass (kg)

Inclination (deg)

Heat Rejection (kW)

Pointing (arcmin)

Data (mbps)

Altitude (km)

Power (kW)

Field of View (deg)

Stability sec/Time

D5

CHARACTERISTICS OF ASTROPHYSICS INSTRUMENTS/FACILITIES

VFX870

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
SOT	8,200	400	57	6.8	0.9	0.025	0.017/90	0.1/15	50
SIRTF	5,300	400	28.5	1.3	0.8	0.125	1.6/20	2/20	1
STARLAB	3,300	400	28	2.2	1.0	0.8	2.5/30	10/30	7
SCRN	3,100	400	57	0.8	0.8	70	CONT	N/A	0.1
SOLAR SOFT X-RAY TELESCOPE	1,300	430	57	0.2	0.2			0.1	
STO	16,600	400	57	9.2		VARIOUS	0.08–120	2–1800	
PINHOLE X-RAY CAMERA	10,000	370	97						
X-RAY OBSERVATORY	3,600	400	28.5	0.9	0.9		1.0		
HRS	1,800	400	< 45	0.5	0.5	10	6/90	36/0.02	0.03
XTE	1,000	400	28.5	0.6	0.6				
AXAF	10 TO 12,000	500	28.5	2.0	2.0		30	1.0	
LAMAR	9,500	400	28	3.4	0.4	1	3/67	10/0.02	0.1
VLBI	1,400	400	57	0.9	0.9	0.1	2.5/45	150/60	12
ASO	12,500	400	57	4.1		0.025	0.17/90	0.1/15	42

COMMUNICATIONS PAYLOADS

VFX887

OBJECTIVES

- Provide Orbital R&D Facilities for Measurement of: Terrestrial Noise; Ionospheric Effects; Tropospheric Dielectric Properties and Transmissibility; Multipath Linkages
- Develop Space Deployment and Calibration Techniques
- Evaluate Millimeter and Optical (Including Laser) Systems
- Develop Potential Application in Nav, Traffic Control, Search and Rescue, etc.

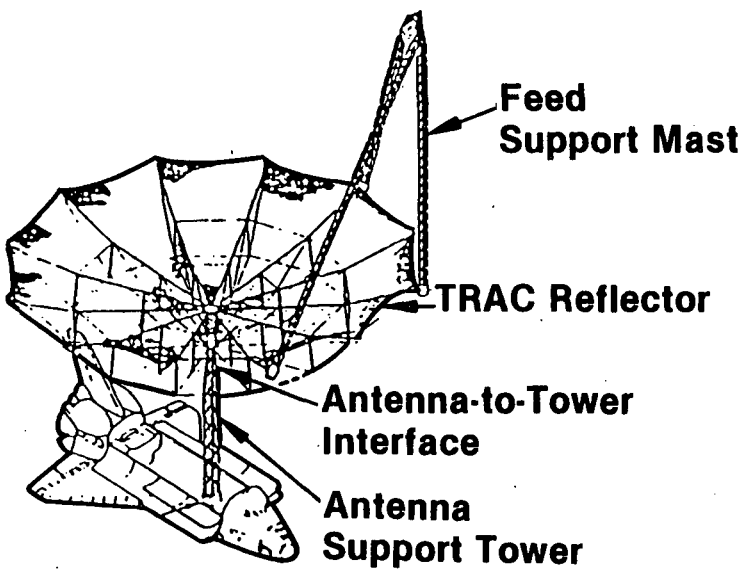
KEY MISSION DRIVERS

- Payloads Sensitive to EMI and RFI
- Require Attitude to Within 1.7 Arc Min
- Require Position to Within 100 Meters
- Continuous Operation of Some Payloads
- Potentially High Data Rates and/or Onboard Storage of Data
- Simultaneous Operation of Multiband Space Transponders and Variety of Antennas
- Multiple Directional Pointing

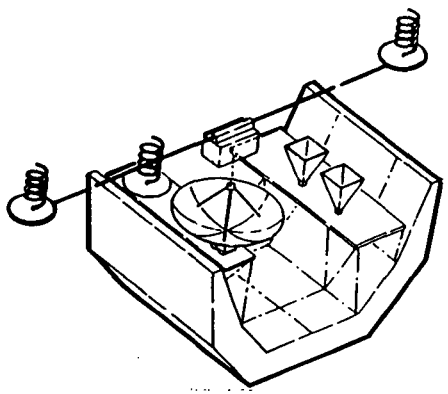
D6

COMMUNICATIONS INSTRUMENTS/FACILITIES

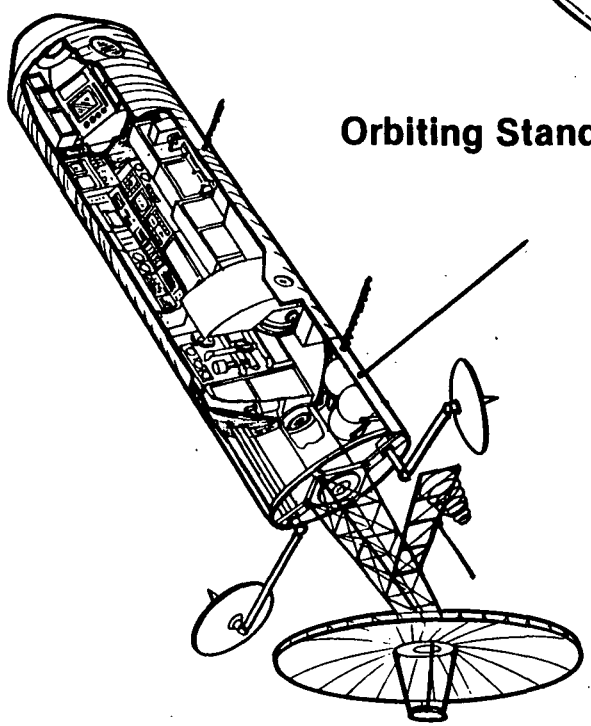
VFX865



Remote Sensing and
RFI Measurements (RFI)



Orbiting Standards Package (OSP)



Manned Communications Research Facility (CRF)

D7

CHARACTERISTICS OF COMMUNICATIONS INSTRUMENTS/FACILITIES

VFX874

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
REMOTE SENSING/RFI	~ 2,500	ANY	> 57	0.12			~ 30	~ 150	0.005
ORBITING STANDARDS PACKAGE	50–100		57	0.15			0.5		0.1
COMMUNICATIONS RESEARCH FACILITY	15,000	435	57	25	25	90	1.7	35	120

EARTH AND PLANETARY EXPLORATION

OBJECTIVES

Development of Remote Sensing Capabilities for

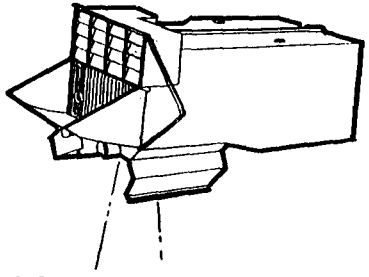
- Earth Resources Assessment
- Crop Monitoring and Forecasts
- Cartography
- Water Resources and Management

KEY MISSION DRIVERS

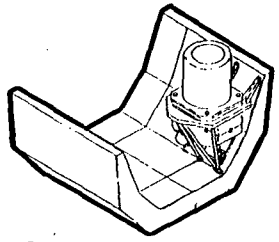
- High Resolution
- Broad Spectral Coverage
- Global Coverage
- Repeatable Ground Track
- High Data Rates (SAR to 120 MBPS)
- High Power (to 6 kW)
- SAR Susceptible to RFI
- Some Instruments May Leak N_2 (IS)
- Simultaneous Operation of Instruments

D8

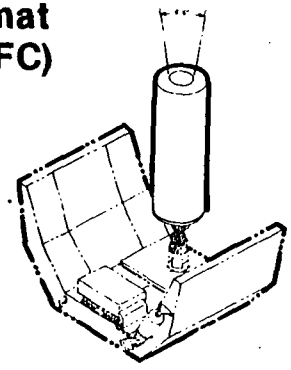
EARTH AND PLANETARY EXPLORATION INSTRUMENTS/FACILITIES



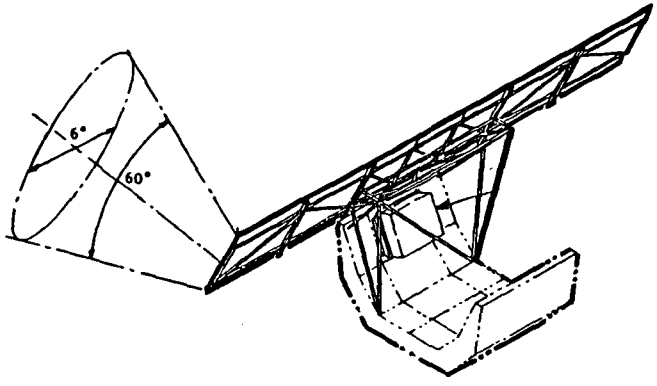
Multispectral Linear Array (Used on Adv Land Obs Sys, ALOS)



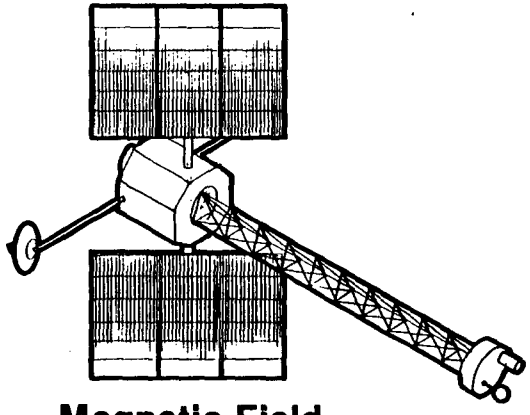
Large Format Camera (LFC)



Imaging Spectrometer (IS)



Synthetic Aperture Radar (SAR)



Magnetic Field Mapper (MFM)

D9

CHARACTERISTICS OF EARTH AND PLANETARY EXPLORATION INSTRUMENTS

VFX873

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
SYNTHETIC APERTURE RADAR	1,900	400	57–90	6.5		6 x 60	60	70	120
ADV LAND OBS SYS	300	4–700	57–98	0.3					
MAGNETIC FIELD MAPPER	800	300	57–97	0.1			30	360	0.02
SNOW AND MOISTURE ASSESSMENT	3–500	465	90	1.2		45	6	100	0.2
LARGE FORMAT CAMERA		250	57				~ 0.5	~ 1	N/A
IMAGING SPECTROMETER	1900	400	57	2.8		8.6	0.5	0.04/0.077	100
FRAUNHOFER LINE DISCRIMINATOR	60	2–800	28–90	0.2		30 x 0.06	0.5	6	
ADVANCED THERMAL MAPPER		400	90						

ENVIRONMENTAL OBSERVATIONS

OBJECTIVES

- Atmospheric and Ocean Observations to Further the Fundamental Understanding of the
  - Solar Terrestrial Interactions
  - Effects of Man on Environment
  - Effects of Natural Phenomena on Environment
- Contribute to the Development of Global Environmental Models

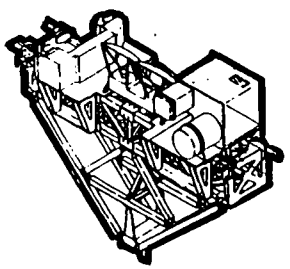
KEY MISSION DRIVERS

- Global Coverage
- Broad Spectral Coverage
- Long-Term/Coordinated Multisensor, Multidirectional Measurements
- High Data Rates (to 120 MBPS)
- Some Instruments Require Cross-Track Scanning/Viewing
- Continuous Operation
- WISP Antenna Extends to 300 (±150) Meters and Must Be Aligned with Respect to Magnetic Field
- High Voltages on HF and VLF Transmitters

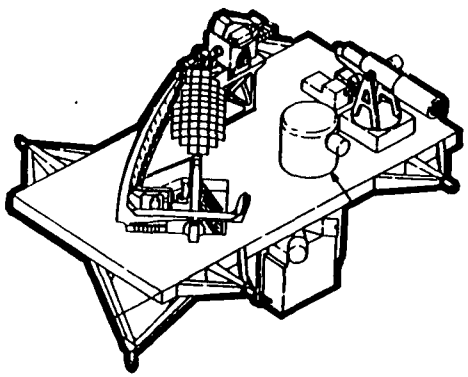
D10

ENVIRONMENTAL OBSERVATIONS INSTRUMENTS/FACILITIES

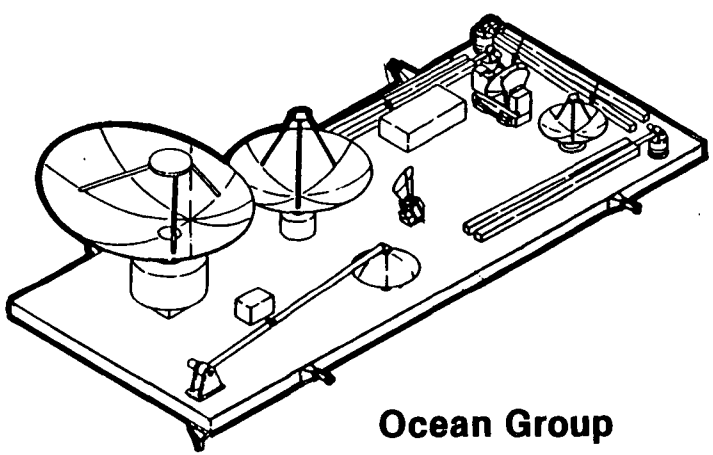
VFX863



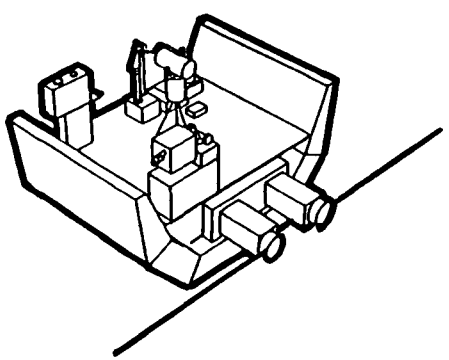
Meteorological Payload (MET)



Upper Atmosphere Research Satellite (UARS)



Ocean Group



Space Plasma Physics (SPP)

D11

CHARACTERISTICS OF ENVIRONMENTAL OBSERVATION PAYLOADS

VFX872

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
OCEAN	10,000	400	57–90	10	10	1	720	720	120
LARS	1,200	780	⩾ 60	1.7					50
UARS	2,400	400	56, 70	1.3	0.8	VARIOUS			0.02
SPACE PLASMA PHYSICS	3,200	3–400	57–90	2.7	1.8	45	60	60	7.5
ZERO-G CLOUD PHYSICS	500	ANY	ANY	1.4		N/A	N/A	N/A	0.5
METEOROLOGY	1,200	400	57	1.2	0.74		6	6	0.01
ICE AND CLIMATE EXPERIMENT	3,500	275	87	2.3					1.4 TO 17.8

LIFE SCIENCES FACILITY PAYLOAD

VFX884

OBJECTIVES

Provide Facilities for

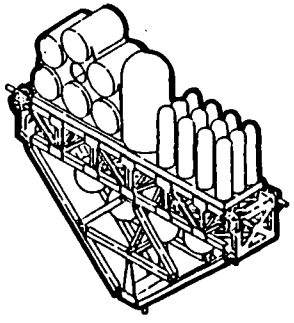
- Understanding the Role of Gravity in Life Sciences
- Addressing the Problems of Long-Duration, Manned Space Missions

KEY MISSION DRIVERS

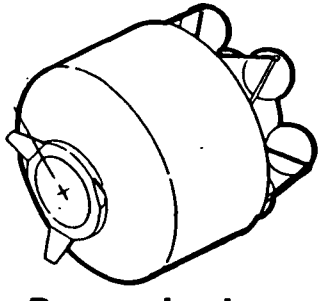
- Low Gravity, $< 10^{-5}$ g's
- Initial Payloads May Operate Unmanned, but "Shirtsleeve" Environment for Active Manned Involvement Desired at Earliest Opportunity
- Living Specimens, Including Man, Serve as Experimental Subjects
- Onboard Centrifugation of Specimens Required
- Continuous Operation Required

D12

LIFE SCIENCES INSTRUMENTS/FACILITIES



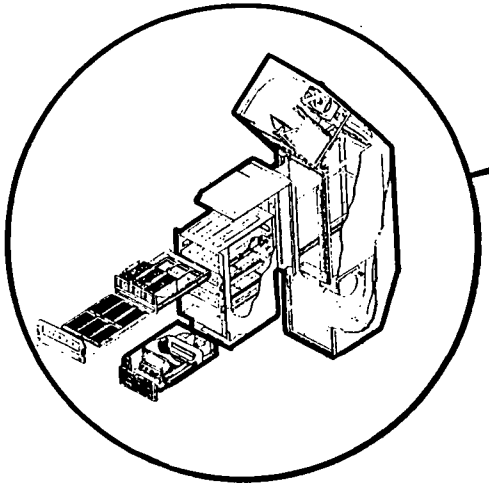
Early Life
Science Payload

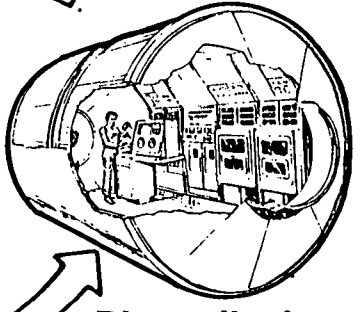


Pressurized
Life Science
Payload

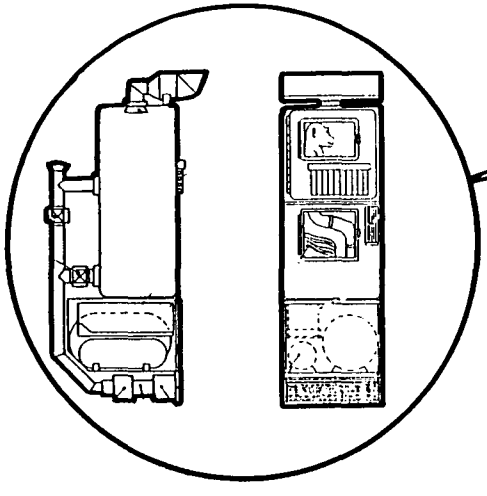
D13

Space Biology
Research Facility (SBRF)





Biomedical
Research
Facility (BRF)



Large Primate Facility (LPF)

CHARACTERISTICS OF LIFE SCIENCES FACILITIES

VFX875

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
LARGE PRIMATE FACILITY	~ 3000	~ 400	ANY	1.8	1.8	N/A	N/A	N/A	0.017
SPACE BIOLOGY RESEARCH FACILITY	~ 3000	~ 400	ANY	3.5	3.5	N/A	N/A	N/A	0.05
BIOMEDICAL RESEARCH FACILITY	~ 3000	~ 400	ANY	2.4	2.4	N/A	N/A	N/A	0.016
ORBITING QUARANTINE FACILITY	~ 3000	~ 400	ANY	1.7	1.7	N/A	N/A	N/A	TBD
EXPERIMENTAL MEDICAL TREATMENT FACILITY	~ 3000	~ 400	ANY	1.2	1.2	N/A	N/A	N/A	TBD

MATERIALS PROCESSING FACILITIES

VFX883

OBJECTIVES

- Utilize the Unique Features of Space to Process Laboratory Quantities of R&D Materials
- Develop Standards
- Verify Conceptual Approaches to Process/Product Development

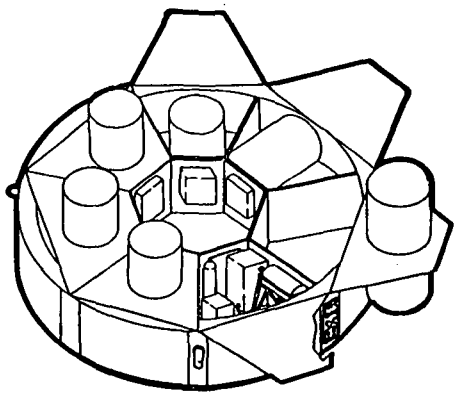
KEY MISSION DRIVERS

- Low Level of Acceleration/Jitter, $< 10^{-5}$ g's
- Vacuum Useful in Some Processes
- Emission of Purge Gases and Process Materials
- High Power Requirements (to 25 kW)
- Long-Duration Missions — Ninety Days or More
- Wide Range of Sample Sizes and Quantities

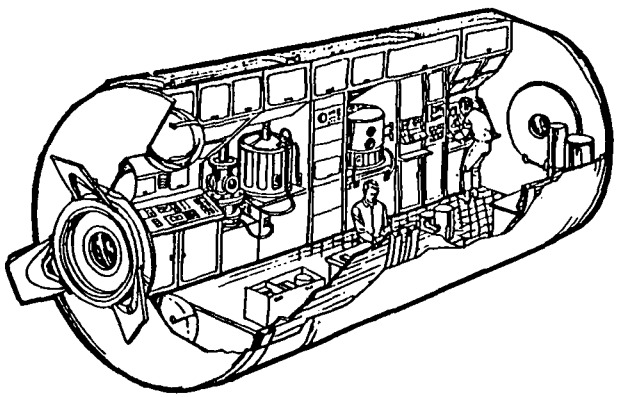
D14

MATERIALS PROCESSING INSTRUMENTS/FACILITIES

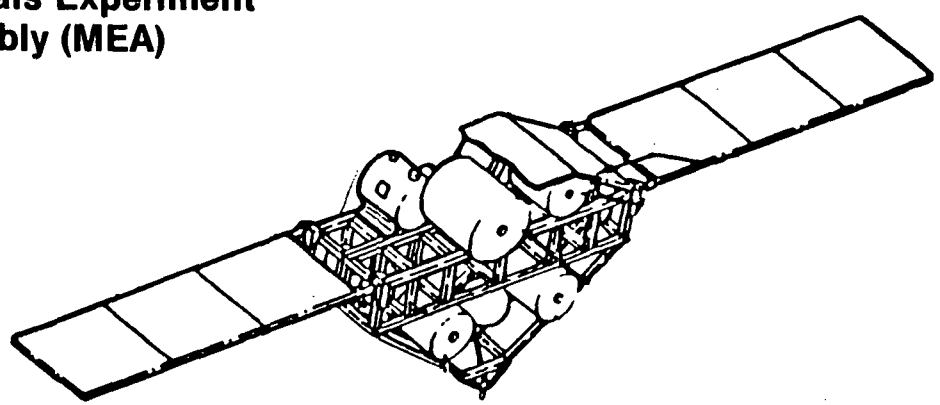
VFX862



Materials Experiment Assembly (MEA)



Materials Research Facility (MRF)



Materials Experiment Carrier (MEC)

D15

CHARACTERISTICS OF MATERIALS PROCESSING FACILITIES

VFX871

	MASS (KG)	ALTITUDE (KM)	INCLINATION (DEG)	POWER (KW)	HEAT REJECTION (KW)	FIELD OF VIEW (DEG)	POINTING (ARC MIN)	STABILITY (ARC SEC/ TIME)	DATA RATE (MBPS)
MATERIAL EXPERIMENT ASSEMBLY	2,200	435	28.5–90	5	5	N/A	N/A	10^{-5} G'S	0.006
MATERIAL EXPERIMENT CARRIER	7,300	435	28.5	12	12	N/A	N/A	10^{-5} G'S	0.5
MATERIAL RESEARCH FACILITY	7,500	~ 400	ANY	25	25	N/A	N/A		10
SPACE VACUUM RESEARCH FACILITY	1,000	400	ANY	4.0		N/A	120		

BENEFITS OF MAN IN ORBIT

Scientist/Observer

- Real-Time Data Analysis
- Multiple Sensor Use
- Sensor Mode/Parameter Selection
- Cooperation With Principal Investigator
- Target Selection

Development Engineer

- Sensor Operation
- Sensor Evaluation
- Component Testing

Technical Operations Specialist

- Equipment Setup, Checkout, Maintenance, Calibration
- Servicing of Sensor and Equipment Consumables

D16

CONCERNS OF MAN IN ORBIT

Safety of Flight

- External Environment
- Physiological Limits
- Psychological Stress
- Onboard Safety

Performance Degradation

- Acceleration Disturbances
- Effluent Release
- Repetitive Duty Cycles

D17

EVALUATION OF MAN IN-ORBIT INFLUENCES

● = REQUIRED
◒ = DESIRABLE
○ = ACCEPTABLE
⊘ = INTOLERABLE
? = EFFECTS UNKNOWN

			ENVIRONMENTAL						LIFE SCIENCES					MPS			
			ICE	MET	OCEAN	SPP	ZERO-g CLOUD	LARS	LPF	SBRF	BRF	OQF	EMTF	MEA	MEC	MRF	VACUUM
BENEFICIAL	SCIENTIST OBSERVER	REAL-TIME DATA ANALYSIS	○	◒	◒	◒	◒	◒	●	●	●	●	●	◒	◒	●	◒
		MULTIPLE SENSOR USE	◒	◒	◒	◒	●	◒	◒	◒	●	◒	●	◒	◒	●	◒
		SENSOR MODE/PARAMETER SELECTION	○	◒	◒	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	●	◒
		COOPERATION WITH PRINCIPAL INVESTIGATOR	◒	◒	◒	◒	●	◒									◒
		TARGET SELECTION	◒	◒	●	◒	●	◒									◒
	DEVEL ENGR	SENSOR OPERATION	◒	◒	◒	◒	●	◒									●
		SENSOR EVALUATION	◒	○	○	◒	●	◒									●
		COMPONENT TESTING	○	○	○	○	◒	○									◒
	TECH OPS	EQUIPMENT SETUP, CHECKOUT, MAINTENANCE, CALIBRATION, ETC	◒	◒	◒	◒	●	◒									●
		SERVICING OF SENSOR AND EQUIPMENT CONSUMABLES	○	◒	◒	◒	●	◒									◒
DETRIMENTAL	SAFETY OF FLIGHT	EXTERNAL ENVIRONMENT	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		PHYSIOLOGICAL LIMITS										○	○	○	○	○	○
		PSYCHOLOGICAL STRESS										○	○	○	○	○	○
		ONBOARD SAFETY										?	?	○	○	○	○
	PERF DEGRAD	ACCELERATION DISTURBANCES	○									○	○	○	○	○	○
		EFFLUENT RELEASE	○									?	?	○	○	○	○
		REPETITIVE DUTY CYCLES	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		SPACE STATION CANDIDATE	○		○	○	●		●	●	●	●	●	○	○	●	●
		PLATFORM CANDIDATE	○	◒	○	◒		○						○	◒		

Required ●
Desirable ◒
Acceptable ○
Intolerable ⊘
Effects Unknown ?

Space Station Candidate

Platform Candidate

D18

EVALUATION OF MAN IN-ORBIT INFLUENCES

VFX878

● = REQUIRED
◒ = DESIRABLE
○ = ACCEPTABLE
⊘ = INTOLERABLE
? = EFFECTS UNKNOWN

			ASTROPHYSICS														
			SOT	SIRTF	STAR LAB	SCRN	SOFT X-RAY	STO	PINHOLE X-RAY	XRO	HRS	XTE	AXAF	LAMAR	VLBI	ASO	
BENEFICIAL	SCIENTIST OBSERVER	REAL-TIME DATA ANALYSIS	●	◒	◒	○	◒	●	○	◒	◒	○	○	○	○	◒	
		MULTIPLE SENSOR USE	◒	○	◒	○	○	◒	○	○	○	○	○	○	○	○	
		SENSOR MODE/PARAMETER SELECTION	◒	◒	◒	○	◒	◒	◒	○	○	○	○	○	○	○	
		COOPERATION WITH PRINCIPAL INVESTIGATOR	◒	◒	◒	○	◒	◒	◒	○	◒	○	○	◒	○	◒	
		TARGET SELECTION	◒	◒	◒	○	◒	◒	◒	◒	◒	◒	◒	◒	○	◒	
	DEVEL ENGR	SENSOR OPERATION	●	●	●	○	○	◒	◒	○	○	◒	◒	○	○	○	
		SENSOR EVALUATION	◒	◒	◒	○	◒	◒	◒	○	○	○	○	○	○	○	
		COMPONENT TESTING	◒	◒	◒	○	◒	◒	◒	○	○	○	○	○	○	○	
	TECH-NICIAN	EQUIPMENT SETUP, CHECKOUT, MAINTENANCE, CALIBRATION, ETC	◒	◒	◒	●	◒	◒	●	◒	◒	◒	◒	●	◒	◒	
		SERVICING OF SENSOR AND EQUIPMENT CONSUMABLES	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒	
DETRIMENTAL	SAFETY OF FLIGHT	EXTERNAL ENVIRONMENT	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
		PHYSIOLOGICAL LIMITS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
		PSYCHOLOGICAL STRESS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
		ONBOARD SAFETY	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
	PERF DEGRAD	ACCELERATION DISTURBANCES	○	○	○	○	○	○	○	○	○	○	⊘	?	⊘	○	
		EFFLUENT RELEASE	○	⊘	○	○	○	○	○	○	○	○	○	○	○	○	
		REPETITIVE DUTY CYCLES	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
		SPACE STATION CANDIDATE	●	◒	●	●	◒	◒	●	○	○						
		PLATFORM CANDIDATE		○			○	○		○	○	○	○	○	○	○	

EVALUATION OF MAN IN-ORBIT INFLUENCES

VFX879

● = REQUIRED
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? = EFFECTS UNKNOWN

			COMM			EARTH/PLANETARY EXPERIMENTS										
			RFI	OSP	CRF	SAR	ALOS	MFM	SMA	LFC	IS	FLD	ATM			
BENEFICIAL	SCIENTIST OBSERVER	REAL-TIME DATA ANALYSIS	○	◒	◒	○	○	○	○	○	○	○	○			
		MULTIPLE SENSOR USE	○	◒	●	○	○	○	○	○	○	◒	◒			
		SENSOR MODE/PARAMETER SELECTION	◒	◒	●	◒	◒	○	○	◒	○	◒	◒			
		COOPERATION WITH PRINCIPAL INVESTIGATOR	◒	◒	◒	○	○	◒	◒	◒	◒	◒	◒			
		TARGET SELECTION	○	○	●	◒	◒	◒	◒	◒	◒	◒	◒			
	DEVEL ENGR	SENSOR OPERATION	◒	◒	●	○	○	◒	◒	◒	◒	◒	◒			
		SENSOR EVALUATION	○	○	◒	○	○	◒	○	○	○	◒	◒			
		COMPONENT TESTING	○	○	◒	○	○	○	○	○	○	○	◒			
	TECH-NICIAN	EQUIPMENT SETUP, CHECKOUT, MAINTENANCE, CALIBRATION, ETC	◒	○	●	◒	◒	◒	◒	◒	◒	◒	◒			
		SERVICING OF SENSOR AND EQUIPMENT CONSUMABLES	◒	◒	◒	◒	◒	◒	◒	●	◒	◒	◒			
DETRIMENTAL	SAFETY OF FLIGHT	EXTERNAL ENVIRONMENT	○	○	○	○	○	○	○	○	○	○	○			
		PHYSIOLOGICAL LIMITS	○	○	○	○	○	○	○	○	○	○	○			
		PSYCHOLOGICAL STRESS	○	○	○	○	○	○	○	○	○	○	○			
		ONBOARD SAFETY	○	○	○	○	○	○	○	○	○	○	○			
	PERF DEGRAD	ACCELERATION DISTURBANCES	○	○	○	○	?	?	○	○	○	○	?			
		EFFLUENT RELEASE	○	○	○	○	○	○	○	○	○	○	○			
		REPETITIVE DUTY CYCLES	○	○	○	○	○	○	○	○	○	○	○			
		SPACE STATION CANDIDATE	○	◒	●	◒		◒	○	●		○	○			
		PLATFORM CANDIDATE	○			○	○	○	○		◒	○	○			

EVALUATION OF MAN IN-ORBIT INFLUENCES

VFX880

● = REQUIRED
◒ = DESIRABLE
○ = ACCEPTABLE
⊘ = INTOLERABLE
? = EFFECTS UNKNOWN

			ENVIRONMENTAL						LIFE SCIENCES					MPS			
			ICE	MET	OCEAN	SPP	ZERO G CLOUD	LARS	LPF	SBRF	BRF	OQF	EMTF	MEA	MEC	MRF	VACUUM
BENEFICIAL	SCIENTIST OBSERVER	REAL-TIME DATA ANALYSIS	○	◒	◒	◒	◒	◒	●	●	●	●	●	◒	◒	●	◒
		MULTIPLE SENSOR USE	◒	◒	◒	◒	●	◒	◒	◒	●	◒	●	◒	◒	●	◒
		SENSOR MODE/PARAMETER SELECTION	○	◒	◒	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	●	◒
		COOPERATION WITH PRINCIPAL INVESTIGATOR	◒	◒	◒	◒	●	◒	◒	◒	◒	◒	●	◒	◒	●	◒
		TARGET SELECTION	◒	◒	●	◒	●	◒	◒	◒	◒	◒	◒	○	○	●	◒
	DEVEL ENGR	SENSOR OPERATION	◒	◒	◒	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	●	●
		SENSOR EVALUATION	◒	○	○	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	◒	●
		COMPONENT TESTING	○	○	○	○	◒	○	○	○	○	○	◒	◒	◒	◒	◒
	TECH-NICIAN	EQUIPMENT SETUP, CHECKOUT, MAINTENANCE, CALIBRATION, ETC	◒	◒	◒	◒	●	◒	◒	◒	●	◒	●	◒	◒	●	●
		SERVICING OF SENSOR AND EQUIPMENT CONSUMABLES	○	◒	◒	◒	●	◒	◒	◒	◒	◒	◒	◒	◒	◒	◒
DETRIMENTAL	SAFETY OF FLIGHT	EXTERNAL ENVIRONMENT	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		PHYSIOLOGICAL LIMITS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		PSYCHOLOGICAL STRESS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		ONBOARD SAFETY	○	○	○	○	○	○	○	○	○	?	?	○	○	○	○
	PERF DEGRAD	ACCELERATION DISTURBANCES	○	⊘	○	○	○	○	○	○	○	○	○	○	○	○	○
		EFFLUENT RELEASE	○	?	○	○	○	○	○	○	○	?	?	○	○	○	○
		REPETITIVE DUTY CYCLES	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
		SPACE STATION CANDIDATE	○		○	○	●		●	●	●	●	●	○	○	●	●
		PLATFORM CANDIDATE	○	◒	○	◒		○						○	◒		

IMPACT OF MANNED PRESENCE ON SCIENCE AND APPLICATIONS

VFX868

Pros

- Responds Creatively As Unanticipated Events or Problems Arise
- Contributes to Assembly, Maintenance, Repair
- Allows Schedule Compression — Reduced Cost and Risk
- Has Unique Perceptual Abilities
- Contribution is Historic Fact

Cons

- Creates Disturbances for Fine Pointing
- Has Physiological and Psychological Performance Limits
- Manned Life Support Systems Can Reduce Viewing Sensitivites

SERVICE MISSIONS IDENTIFIED SCIENCE AND APPLICATIONS

Missions	Mass (kg)	Altitude (km)	Inclination (deg)	Service Requirements
Space Telescope	11,000	600	28.8	Repair, 5-year Refurbishment
SIDM	2,600	575	28/98	Propellant Resupply, Refurbishment
LDR	20,500	700	28	Cryogen Resupply, Refurbishment, Reboost
Gamma Ray Observatory	11,000	400	28.5	Repair, Propellant Resupply, Refurbishment
LANDSAT D-D'	1,600	705	97	Repair, Refurbishment
GRAVSAT-B				Cryogen Resupply, Refurbishment, Reboost
UARS	2,400	500	56, 70	Cryogen Resupply, Repair, Refurbishment
TIROS-N	740	830	90	Repair, Refurbishment

SCIENCE AND APPLICATIONS MISSION ALLOCATION STATUS

VFX869

ALLOCATED TO SPACE STATON — 15

- SOT
- OSP
- SBRF
- MRF
- STARLAB
- LFC
- BRF
- Vacuum
- SCRN
- Zero g Cloud
- OQF
- CRF
- Pinhole X-Ray
- LPF
- EMTF

ALLOCATED TO SPACE STATION OR PLATFORM — 17

- SIRTF
- HRS
- MFM
- ICE
- MEC
- Soft X-Ray
- ASO
- SMA
- Ocean
- STO
- RFI
- FLD
- SPP
- XRO
- SAR
- ATM
- MEA

ALLOCATED TO SPACE PLATFORM — 8

- XTE
- ALOS
- AXAF
- IS
- LAMAR
- MET
- VLBI
- LARS

ALLOCATED TO FREE FLYER SERVICE — 8

- Space Telescope
- LANDSAT D-D'
- SIDM
- GRAVSAT-B
- LDR
- UARS
- GRO
- TIROS

D19

MISSION REQUIREMENTS (TASK 1) CANDIDATE COMMERCIAL MISSIONS

Dr. Harry Wolbers

COMMERCIAL USES OF SPACE
PAST EXPERIENCE

VFY168

- Substantial Survey Work Since 1972
  - — (e.g.: GE, TRW, SAI, RI, MDAC)
- Typical Results of Prior Studies
  - — Few Concepts Stand Up Under Scrutiny
  - — Attractive Alternatives - Less Expensive
  - — Products and Markets Poorly Defined
  - — Risks High - Many Unknowns
  - — Long Time Delay - Concept to Implementation
  - — Payback Period Long for Capital Outlay Required
  - — Protection of Proprietary Rights Critical

E1

COMMERCIAL USES OF SPACE
CURRENT STATUS

VFY169

- Only One Potential Product for Space Manufacturing Has Reached Testing Stage — (Electrophoresis Operations)
- Interest in Space Exists
- Companies Want to Stay Ahead of Competition
- Risk Reducing/Sharing Policies Would Spur Interest
- Continuing Dialog With Potential Users Required

E2

COMMERCIAL USERS INTERACTION STRATEGY

VFY139

PROCEDURE

- Develop Case Study As Example
- Establish Continuing Dialog and In-Depth Interviews With Selected Users

RESULTS TO DATE

- Relationships With 18 Corporate Entities Established (8 Booz Allen, 10 MDAC)
- 25 In-Depth Interviews (15 Booz Allen, 10 MDAC)
- 12 Potential Commercial Missions Identified
- 59 Products/Processes Identified to Date

E3

TWELVE POTENTIAL COMMERCIAL MISSIONS IDENTIFIED TO DATE

VFY006

MDAC Data Bank Identifier		Areas of Responsibility		
		MDAC HB	MDAC STL	BAH
CIR001	Materials Research Facility	●	○	
CMP001	Electrophoretic Processes		●	
CMP002	Silicon Ribbon Manufacture		●	
CMP003	Crystals/Diffractors	○		●
CMP004	Melting/Refreezing	○		●
CMP005	Homogeneous Mixtures	○		●
CMP006	Directional Crystal Growth	○		●
CMP007	Hot/Cold Processes	○		●
CMP008	Unidirectional Processes	○		●
CMP009	Earth Observations	○		●
CMP010	Materials Production	○		●
CMP011	Misc Operations	○		●

● Product Definition
○ System Support

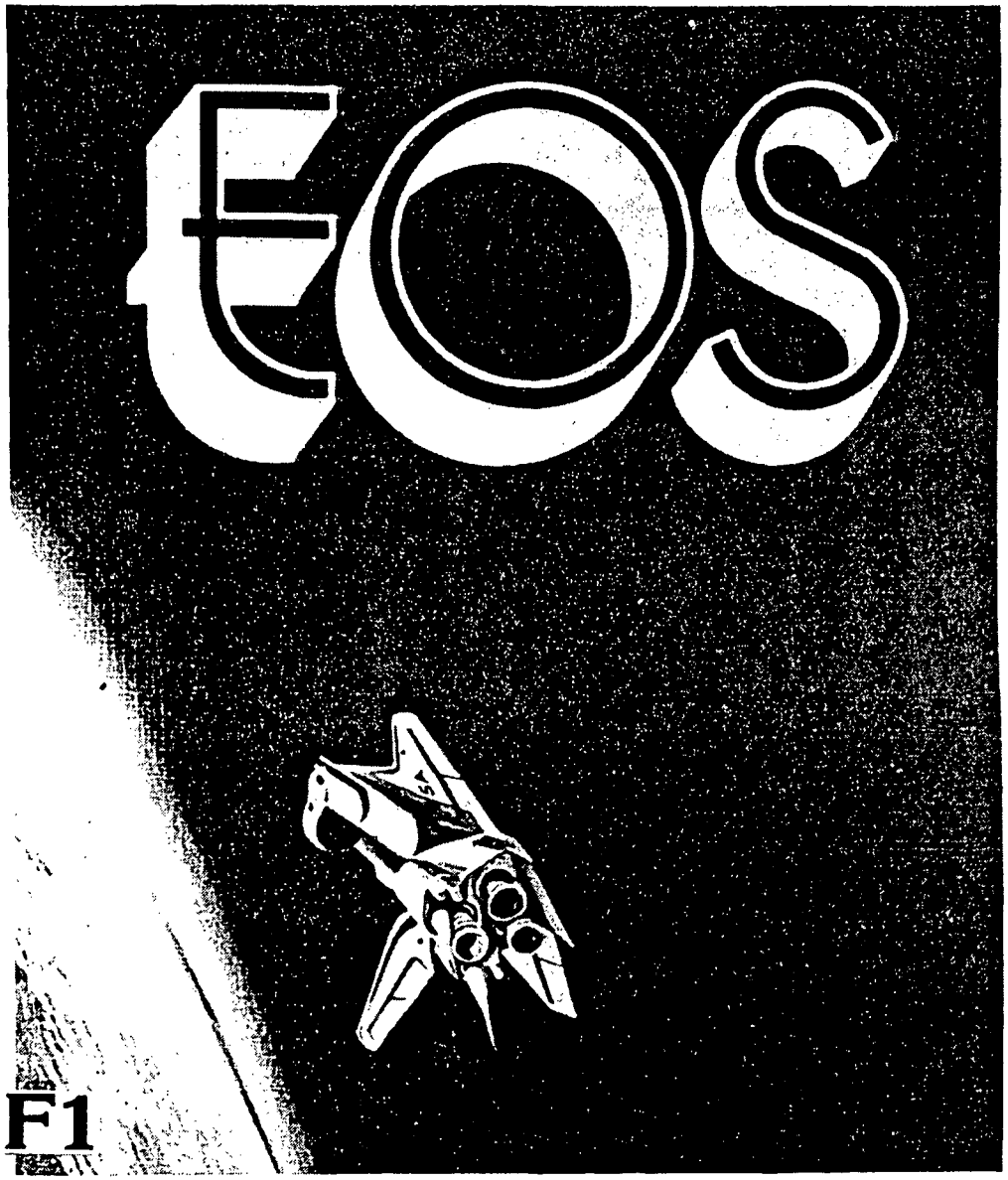
E4

MISSION REQUIREMENTS (TASK 1) SELECTED COMMERCIAL MISSIONS

Jim Rose — MDAC St. Louis

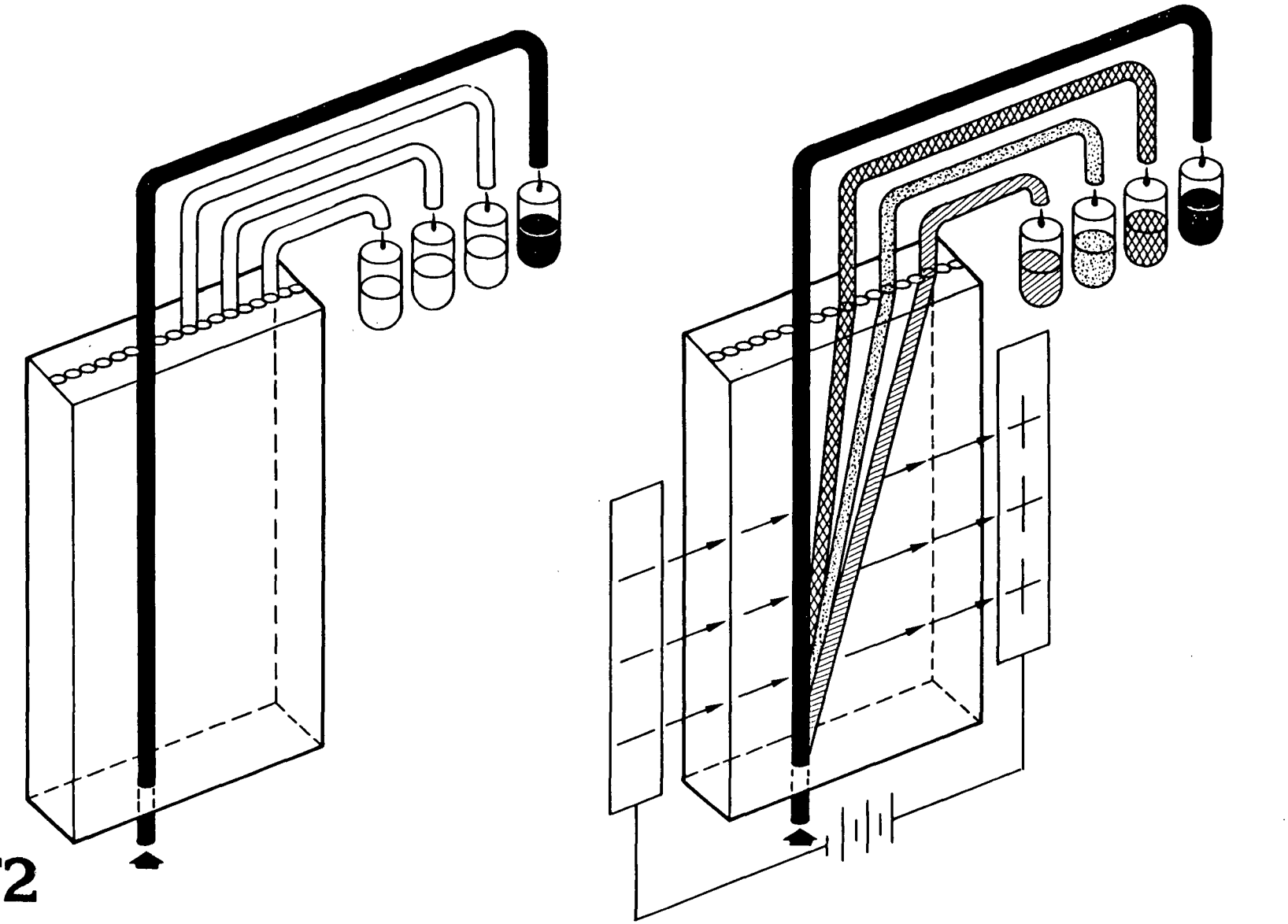
CASE HISTORY OF A COMMERCIAL SPACE MISSION

VFY047



- Potential Benefits
- Program Characteristics
- Development Considerations
- Manned Space Station Operations

CONTINUOUS FLOW ELECTROPHORESIS



F2

VFY049

POSSIBLE PRODUCTS UTILIZING EOS TECHNOLOGY

Field	Types of Products
Pharmaceuticals	Enzymes, Hormones, Other Proteins, Cells
Diagnostics	Monoclonal Antibodies, Hormones for Radioimmunoassays
Veterinary	Enzymes, Hormones, Other Proteins, Spermatozoa, Other Cells
Agrichemicals	Growth Stimulants, Pathogens
Food Products	Additives

F3

EXAMPLES OF BENEFICIAL BIOLOGICAL PRODUCTS

VFY050

Product	Product Objective	Current Status
Growth Hormone (850,000)*	Stimulates Juvenile Bone Growth, Promotes Healing of Ulcers	Research Quantities, Low Purity
Beta Cells (3,200,000)	Single Injection Cure for Diabetes	Clinical Quantities Not Separable
α - Antitrypsin (500,000)*	Limit Emphysema Disease State, Enhance Cancer Chemotherapy	Research Quantities, Low Purity
Epidermal Growth Factor (1,100,000)*	Skin Burn and Wound Healing	Research Quantities, Low Purity
Interferon (20,000,000)*	Viral Infection Immunity	Low Yield and Purity
Antihemophilic Factor (15,000)*	Eliminate Immunological Reactions for Hemophilia	Low Purity and Loss of By-Products

*Annual Patient Load — U.S. Market

F4

VFY051

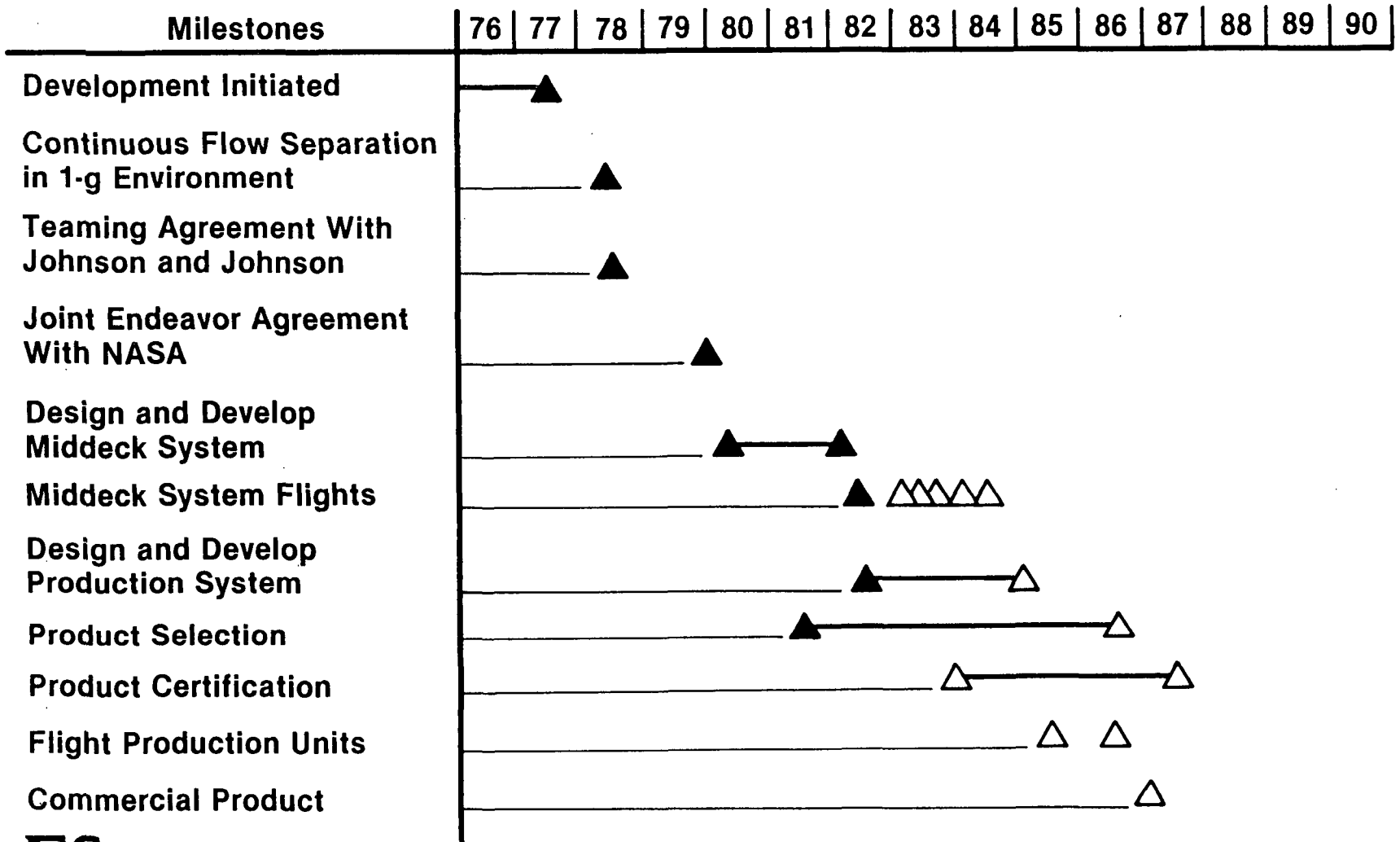
CHARACTERISTICS OF THE EOS PROGRAM

- Cooperative Venture
  - (1) Within Industry: MDAC for Aerospace, Johnson and Johnson (J&J) for Pharmaceuticals
  - (2) With Government: NASA for Shuttle Launch and Support
- High Technology Activity
  - (1) New Process Development Required
  - (2) New Product Development Required
- Proprietary Marketable Products
  - (1) Impressive Medical Benefits Possible
  - (2) Low Weight/High Value
  - (3) Projected Positive Return on Investment (ROI)
- Successful Early Development Effort

F5

EVOLUTION OF A COMMERCIAL SPACE PROGRAM

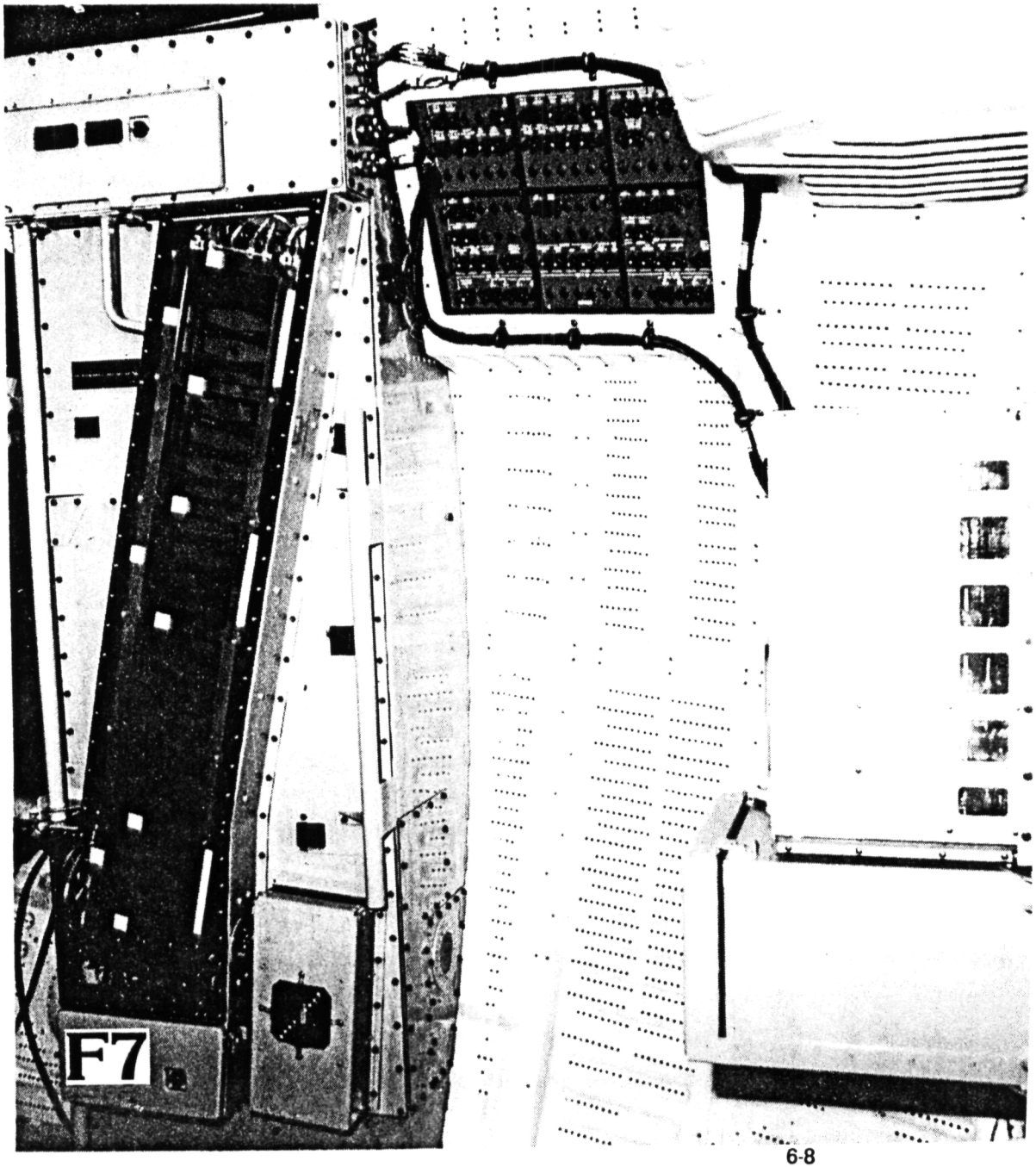
VFY052



F6

EOS MIDDECK SYSTEM

VFY053



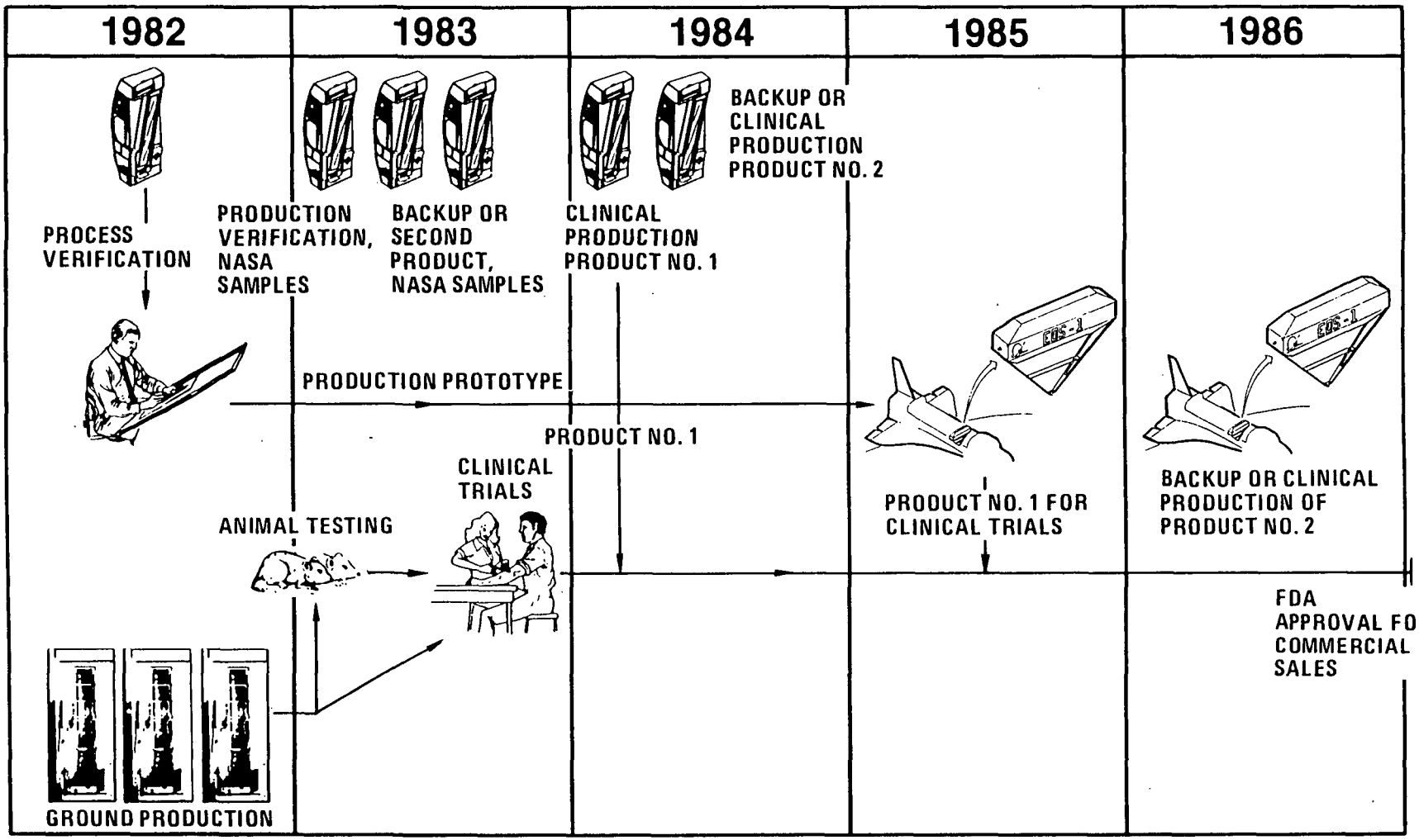
Flight Dates Under Joint Endeavor Agreement

STS	4	July	1982
	6	Jan	1983
	7	April	1983
	8	July	1983
	11	Jan	1984
	14	May	1984

Results From First STS Flight

1. 500 Times Increase in Yield
2. Quantitatively Repeatable Separation
3. Validated Design Concepts

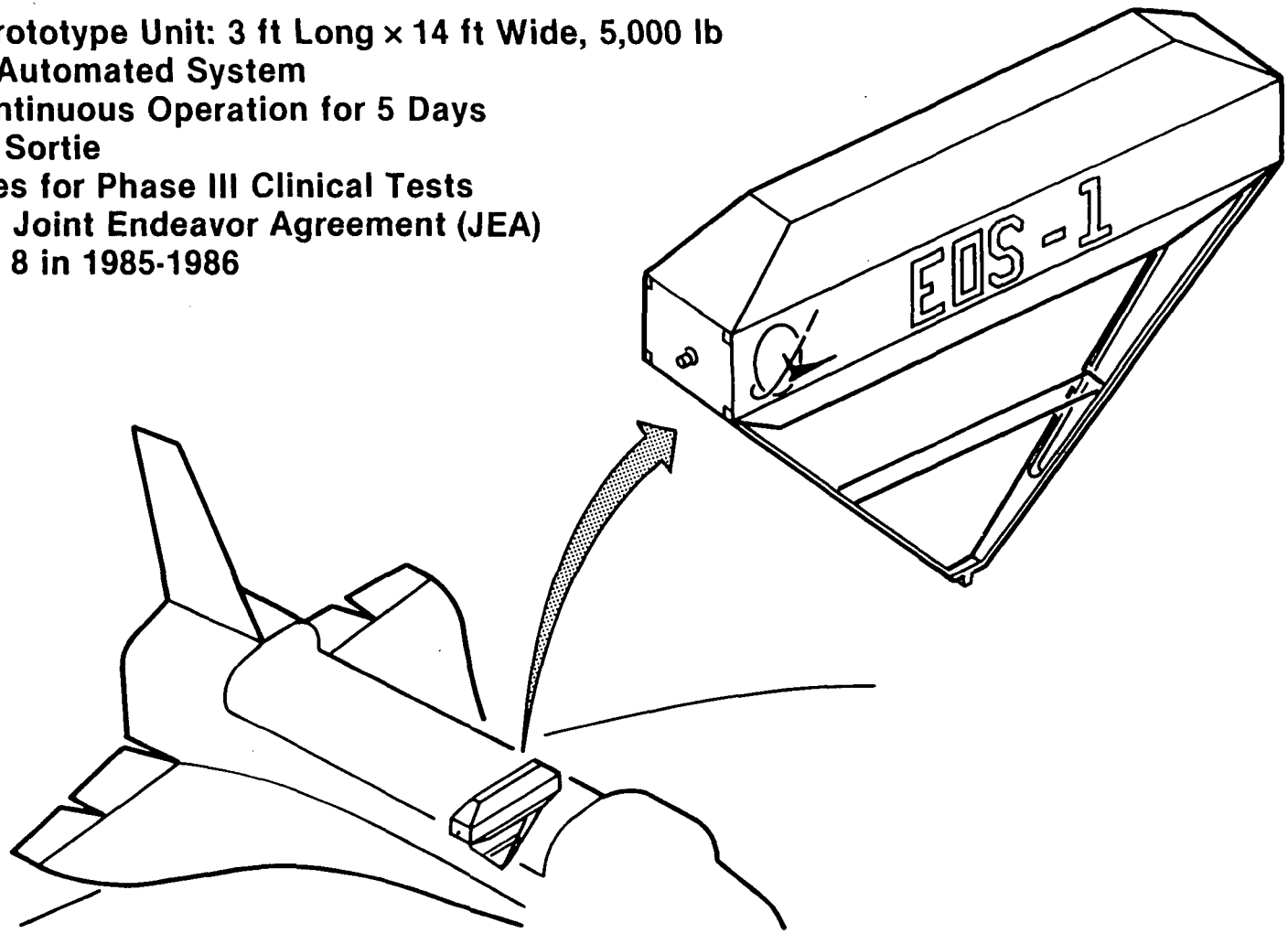
STEPS TO COMMERCIAL OPERATIONS



F8

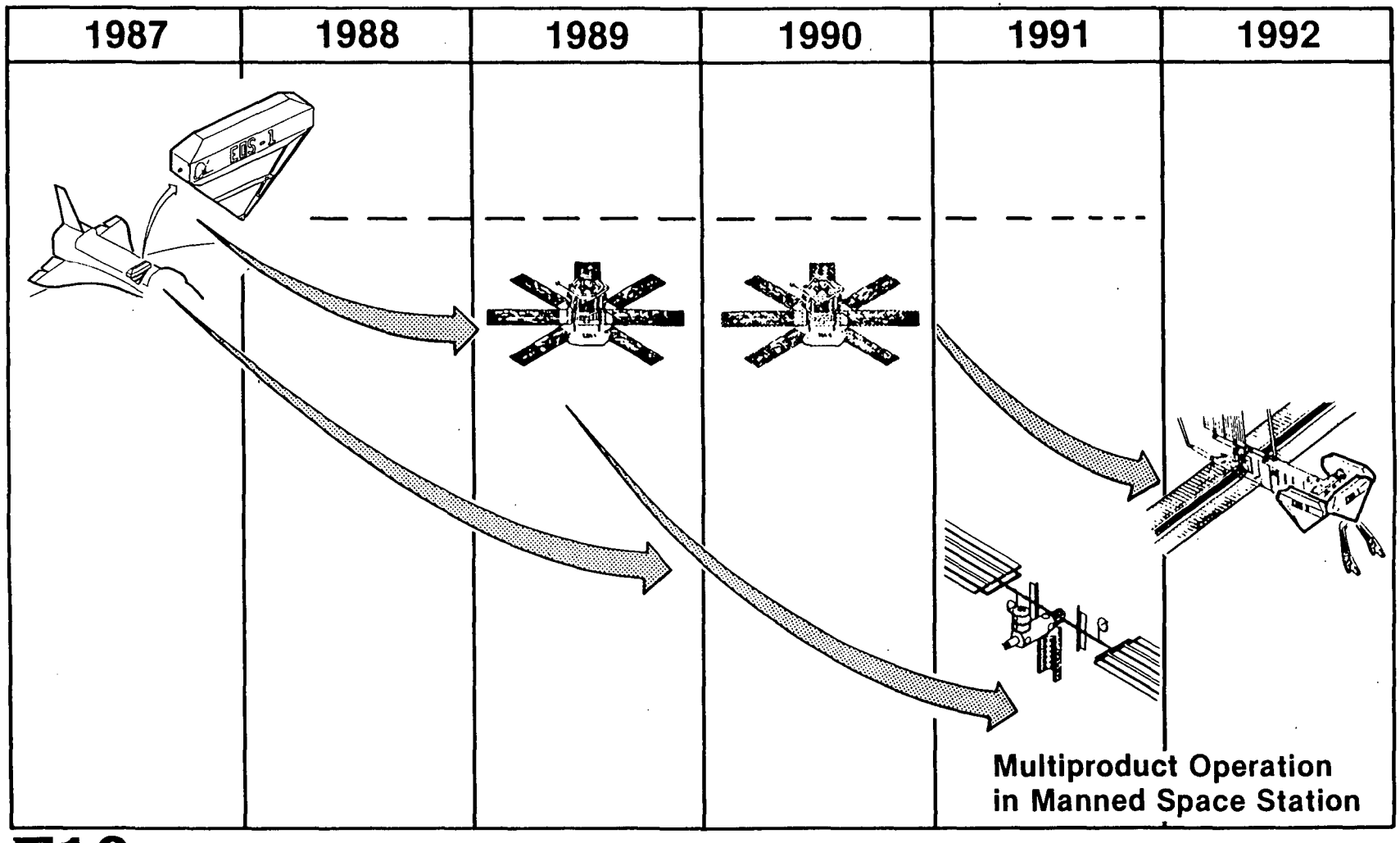
PRODUCTION PROTOTYPE IN SHUTTLE PAYLOAD BAY

- Production Prototype Unit: 3 ft Long x 14 ft Wide, 5,000 lb
- 24-Chamber, Automated System
- Checkout Continuous Operation for 5 Days During 7-Day Sortie
- Produce Doses for Phase III Clinical Tests
- Scheduled as Joint Endeavor Agreement (JEA) Flights 7 and 8 in 1985-1986



F9

COMMERCIAL OPERATIONS ALTERNATIVES



F10

CONSIDERATIONS IN DEVELOPMENT OF NEW COMMERCIAL SPACE PRODUCTS

VFY057

- Requires Verification and Development of Space Processes and Products
- Significant Investment Capital at High Risk
- Unproven Markets for New Products
- Elapsed Time to Marketable Product Is Significant
- Vulnerable Proprietary Rights
- Dependence on Supporting Government Space Facilities
- Technology Obsolescence

F11

STEPS FOR NEW BIOLOGICAL PRODUCT DEVELOPMENT

VFY058

	Unmanned Free-Flyer Mode			Manned Space Station Mode
	Middeck or Spacelab	Payload Bay	Unmanned Free-Flyer	
Characterization	✓			✓
Clinical Trial Materials		✓		✓
Initial Commercial Production		✓ (Interim)	✓	✓
Expanded Production			✓	✓

F12

VFY059

MANNED SPACE STATION SHOWS SIGNIFICANT IMPROVEMENT OVER UNMANNED PLATFORM ON PRODUCT PRICE TO PATIENT

	Unmanned Operations Mode	Manned Operations Mode
Relative Cost of Front-End Expense	1	0.38
Relative Cost of Operating Expense	1	0.77
Relative Number of New Products Developed	1	5.0

F13

MANNED SPACE STATION OPERATION

Enhances Rate of New Product Additions

- Fifteen Products Can Be Added in 10 Years With Space Station Compared With Three Products for Unmanned Free-Flyer
- Product Characterization Time Is Reduced From 1 or 2 Years to a Few Months
- Production Time for Clinical Materials Is Reduced From 1 or 2 Years to a Few Months
- Dedicated Section of Plant and Manned Operation Allow Many Products to Be Evaluated or Produced in Short Runs in Same Time Frame

F14

MISSION REQUIREMENTS (TASK 1) SELECTED COMMERCIAL MISSIONS

Dr. Myron Weinberg — Booz, Allen and Hamilton

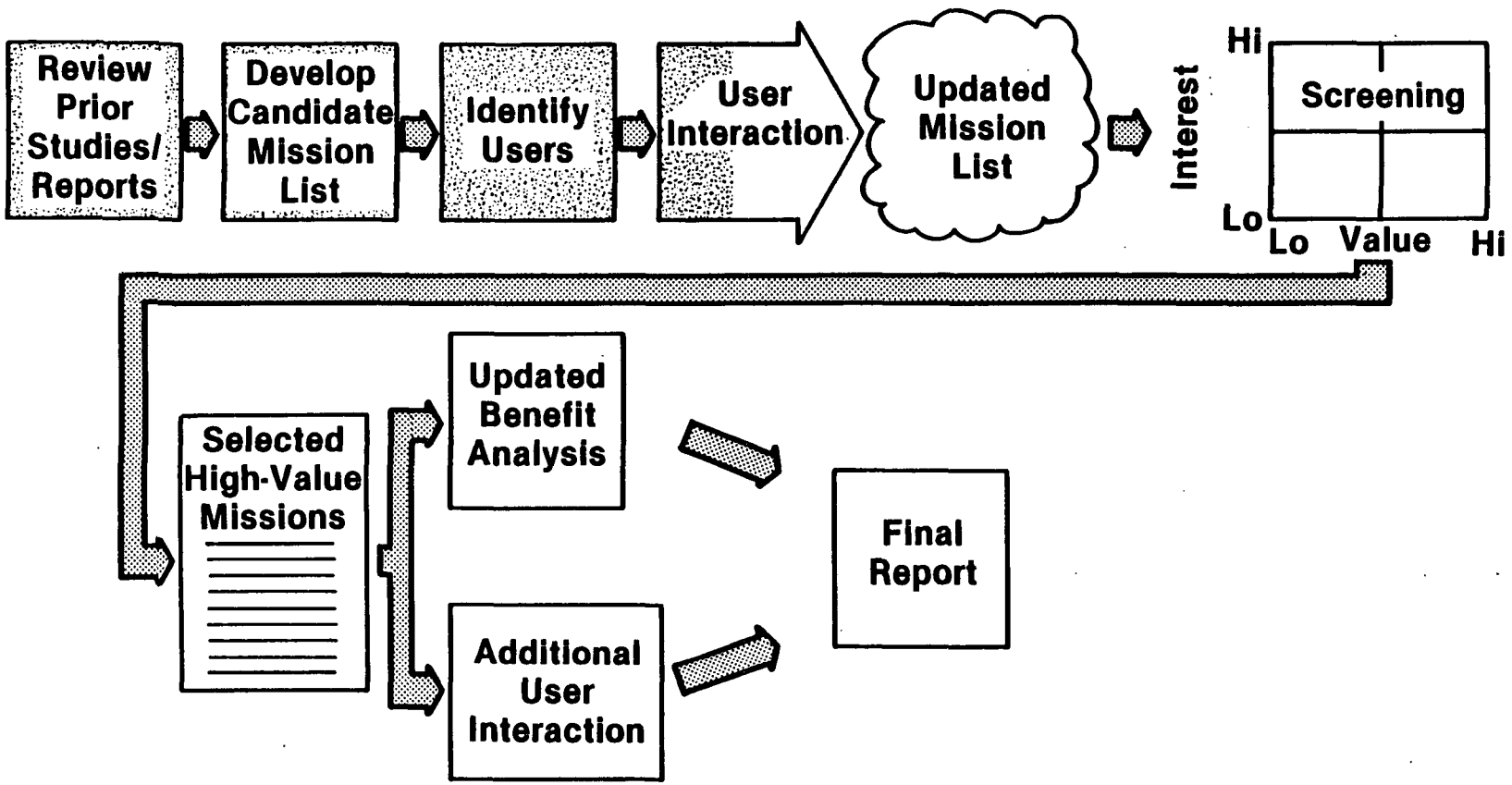
OBJECTIVES

- Identify Missions and Introduce Space Station Opportunities to Potential Commercial Users
- Develop "Real World" Qualified List of Commercial Missions
- Identify Broad Space Station Requirements for the Selected Missions

G1

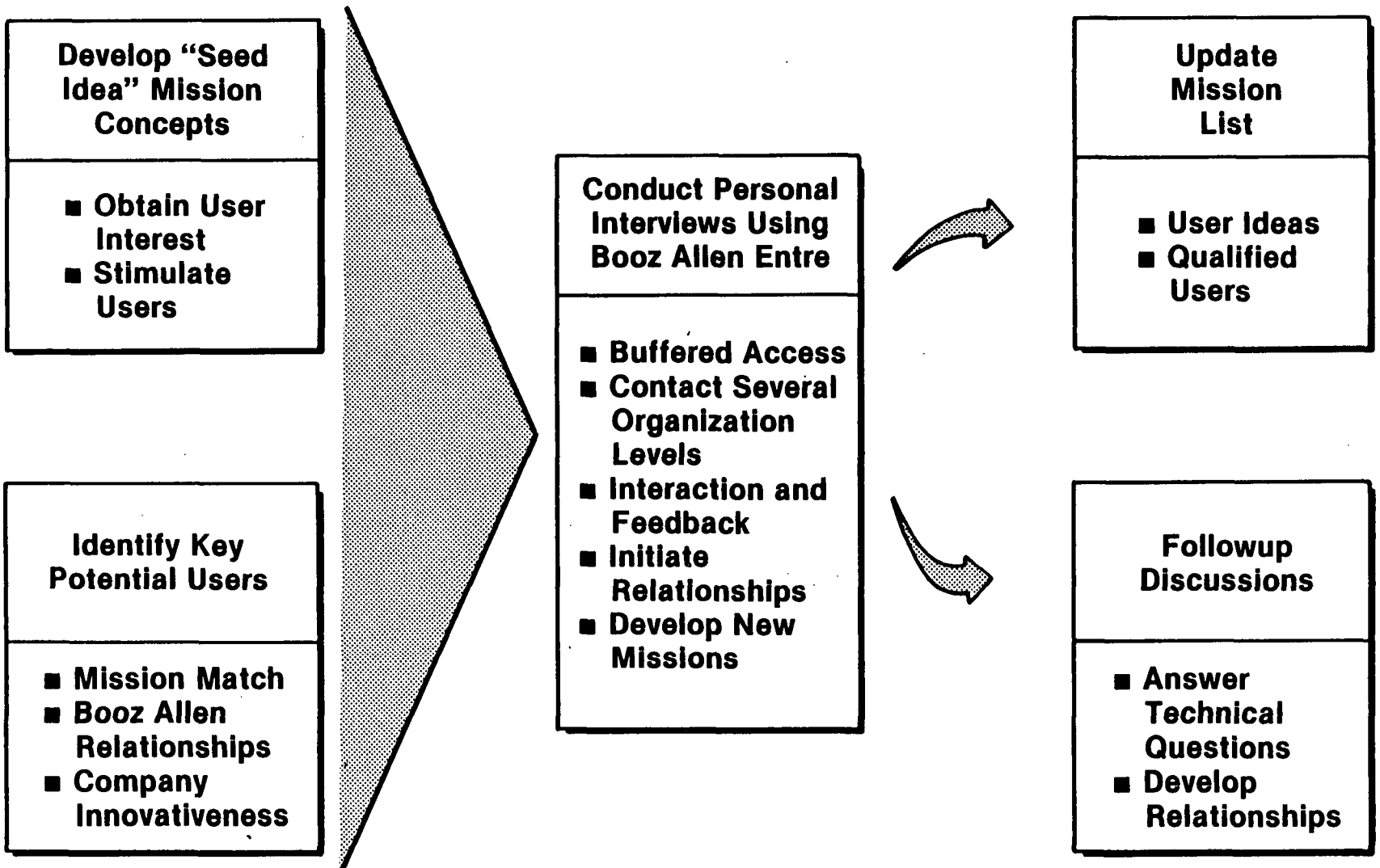
OVERALL APPROACH TO COMMERCIAL MISSION SELECTION AND ANALYSIS

VFX846



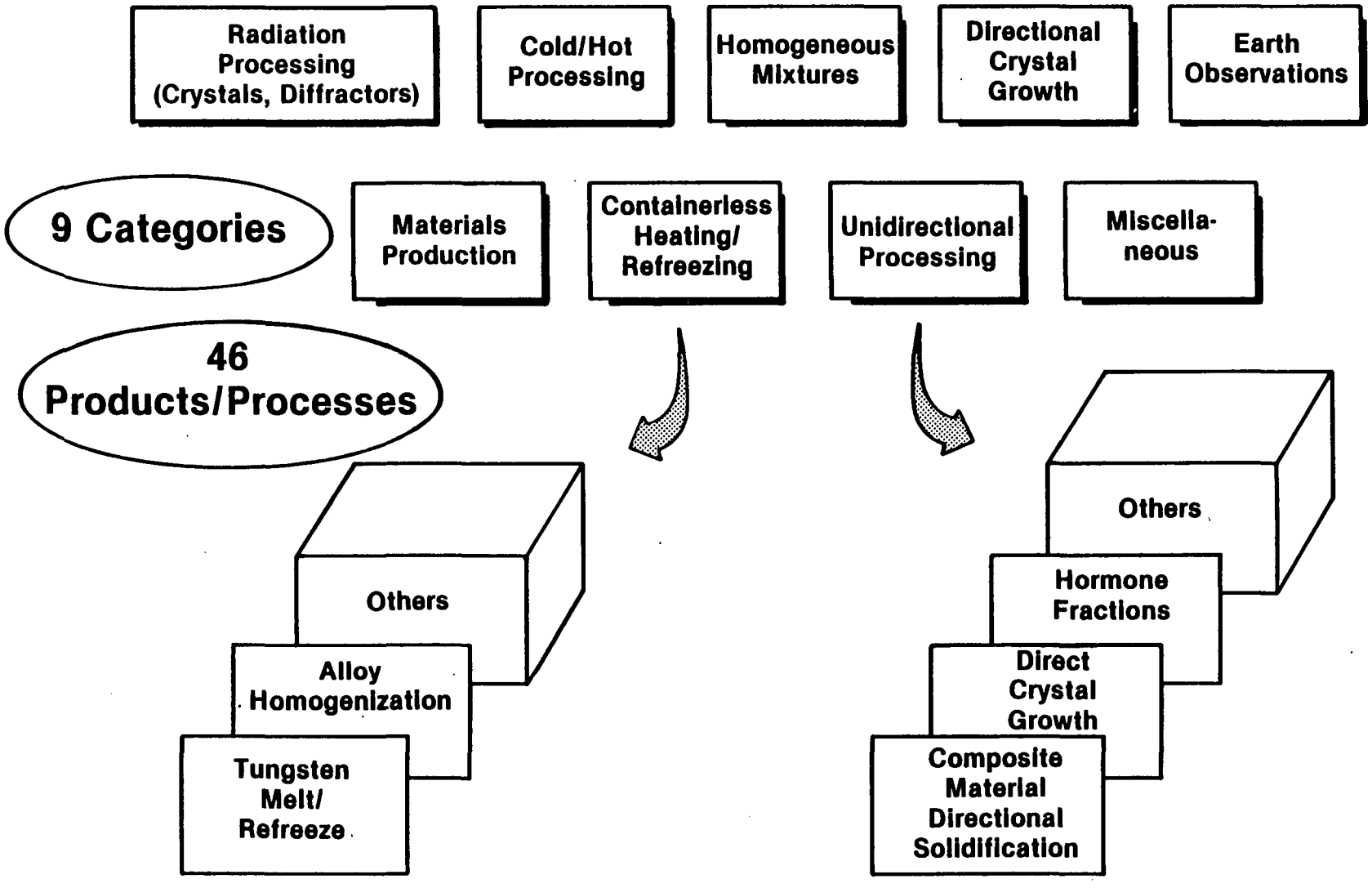
G2

KEY ELEMENTS OF BOOZ ALLEN APPROACH



G3

COMMERCIAL AREAS OF INTEREST



G4

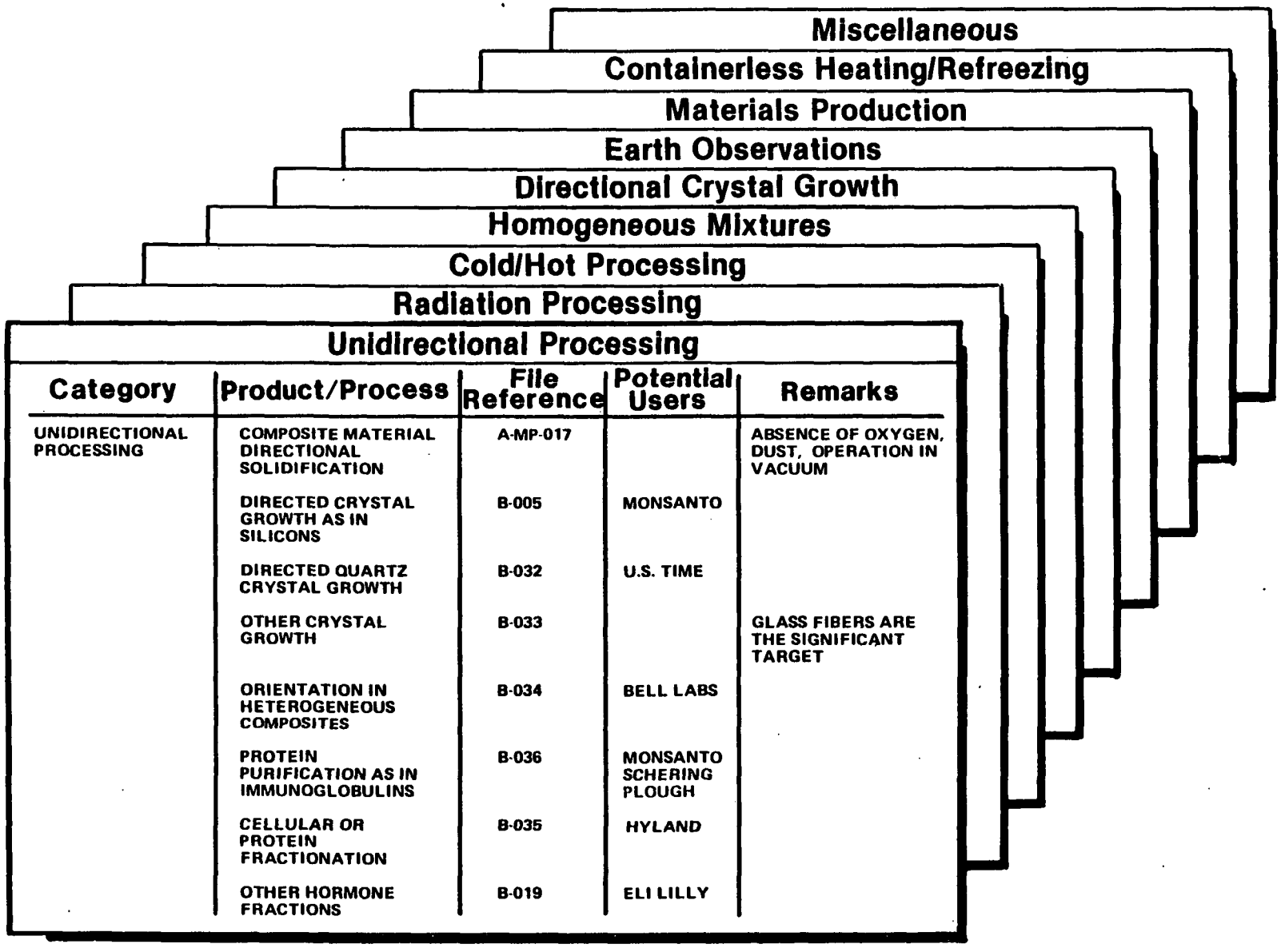
CANDIDATE MISSION SUMMARY

Category	Product/Process	File Reference
Unidirectional Processing	Composite Material Directional Solidification	A-MP-017
	Directed Crystal Growth as in Silicons	B-005
	Directed Quartz Crystal Growth	B-032
	Other Crystal Growth	B-033
	Orientation in Heterogeneous Composites	B-034
	Protein Purification as in Immunoglobulins	B-036
	Cellular or Protein Fractionation	B-035
	Other Hormone Fractions	B-019

G5

46 CANDIDATE PRODUCTS/PROCESSES AND POTENTIAL USERS

VFX849



Category	Product/Process	File Reference	Potential Users	Remarks
UNIDIRECTIONAL PROCESSING	COMPOSITE MATERIAL DIRECTIONAL SOLIDIFICATION	A-MP-017		ABSENCE OF OXYGEN, DUST, OPERATION IN VACUUM
	DIRECTED CRYSTAL GROWTH AS IN SILICONS	B-005	MONSANTO	
	DIRECTED QUARTZ CRYSTAL GROWTH	B-032	U.S. TIME	
	OTHER CRYSTAL GROWTH	B-033		GLASS FIBERS ARE THE SIGNIFICANT TARGET
	ORIENTATION IN HETEROGENEOUS COMPOSITES	B-034	BELL LABS	
	PROTEIN PURIFICATION AS IN IMMUNOGLOBULINS	B-036	MONSANTO SCHERING PLOUGH	
	CELLULAR OR PROTEIN FRACTIONATION	B-035	HYLAND	
	OTHER HORMONE FRACTIONS	B-019	ELI LILLY	

G7

CANDIDATE MISSION SUMMARY

Category	Product/Process	File Reference	Potential Users
Unidirectional Processing	Composite Material Directional Solidification	A-MP-017	
	Directed Crystal Growth as in Silicons	B-005	Monsanto
	Directed Quartz Crystal Growth	B-032	U.S. Time
	Other Crystal Growth	B-033	
	Orientation in Heterogeneous Composites	B-034	Bell Labs
	Protein Purification as in Immunoglobulins	B-036	Monsanto Schering Plough
	Cellular or Protein Fractionation	B-035	Hyland
	Other Hormone Fractions	B-019	Eli Lilly

G6

TARGET USERS 1

American Telephone and Telegraph Company	Homogenous Mixtures, Directional Crystal Growth
E. I. Dupont & Company	Homogenous Mixtures, Directional Crystal Growth, Undirectional Processing
Monsanto Company	Homogenous Mixtures, Directional Crystal Growth, Undirectional Processing
Allegheny International	Cold/Hot Processing, Homogenous Mixtures, Containerless Heating/Refreezing
Johnson Matthey Company	Cold/Hot Processing, Containerless Heating/Refreezing
Perkin Elmer, Inc.	Directional Crystal Growth, Radiation Processing

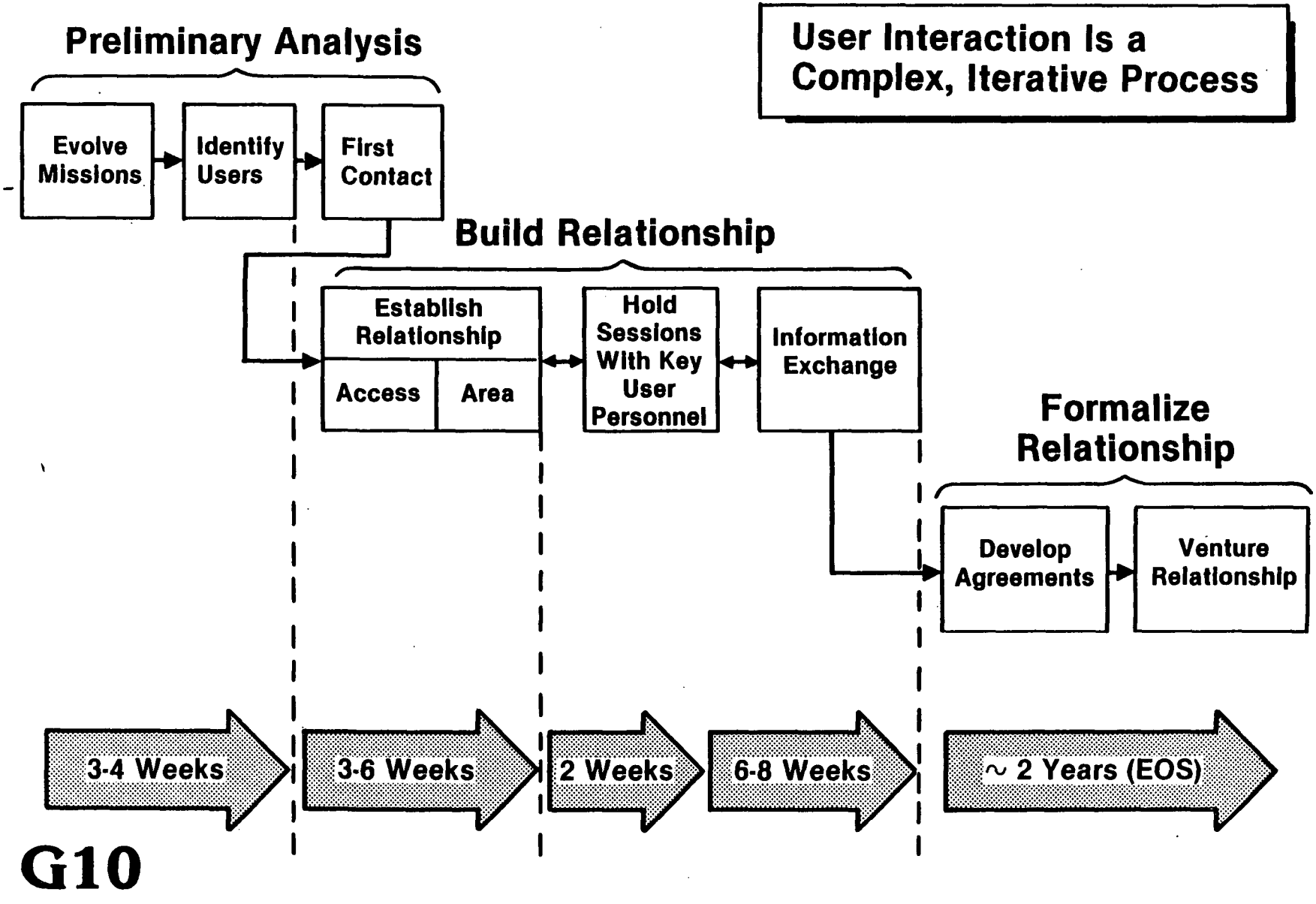
G8

TARGET USERS 2

Celanese, Inc.	Homogenous Mixtures, Cold/Hot Processing
Eli Lilly Co., Inc.	Homogenous Mixtures, Unidirectional Processing
Union Carbide, Inc.	Earth Observations
The Fluor Corporation	Cold/Hot Processing, Homogenous Mixtures, Containerless Heating/Refreezing, Unidirectional Processing
International Business Machines	Directional Crystal Growth, Containerless Heating/Refreezing
Eastman Kodak	Directional Crystal Growth
Baxter Travenol	Unidirectional Processing, Homogenous Mixtures, Containerless Heating/Refreezing
Department of Defense	Miscellaneous — Medical Uses
Environmental Protection Agency	Earth Observations

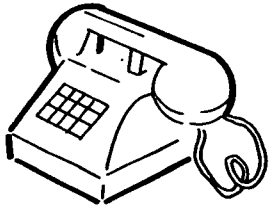
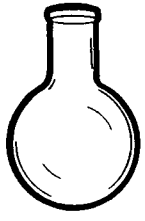
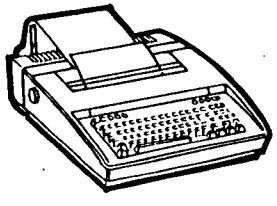
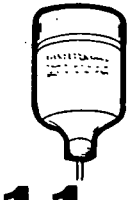
G9

USER INTERACTION



G10

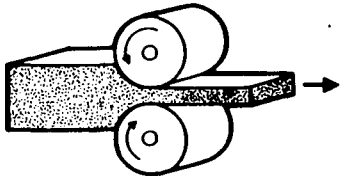
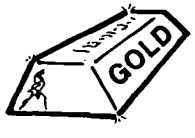
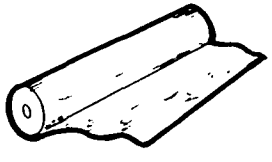
USER INTERACTION RESULTS TO DATE

USER	RESPONSE
 American Telephone and Telegraph Company	■ Interest in New Product Identified — Up-Coming Concept Meeting
 Monsanto	■ Three Major Areas of Processing Identified — Planning Meeting to Be Set
 International Business Machines	■ Unique Area of Interest Identified — Concept Meeting Week of November 16, 1982
 Baxter Travenol	■ Three Major Areas of Interest in New Products — Concept Meeting on November 16, 1982

G11

USER INTERACTION RESULTS TO DATE (CONT)

VFX853

USER	RESPONSE
 Eli Lilly and Company	■ Two Areas of Processing Interest Identified — Concept Meeting on November 17, 1982
 Allegheny International	■ Specific New Product Idea Identified by Allegheny — Meeting on Environmental Requirements Set for Week of December 1, 1982
 Johnson Matthey	■ Identified — Meeting Week of November 22, 1982
 Celanese	■ First Concept Meeting Completed — Technical Analysis of a New Concept Generated

G12

TYPICAL USER INTERACTION RESULTS
(CELANESE MEETING)

VFX857

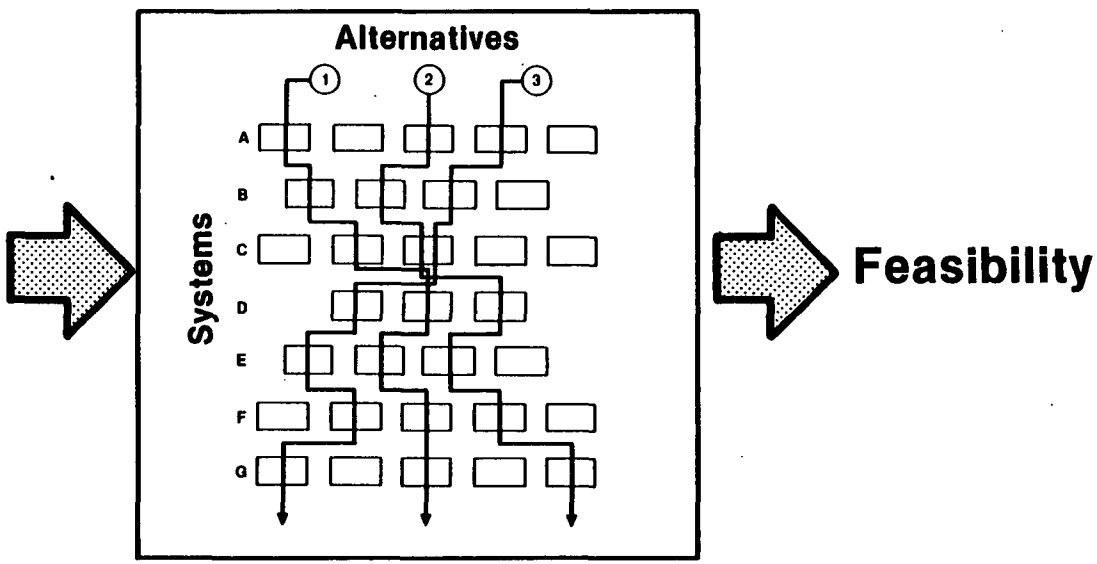
Our Initial Meeting With Celanese Is an Example of the Results of Our Contacts to Date

- **The Meeting Involved Discussion of Our Concepts — One Major New Idea Was Developed by Celanese**
- **Several Detailed Technical Questions Were Asked**
- **Tehnical Analysis of These Questions Is Required Before Followup Is Possible**
- **Proprietary Rights Were Discussed**

G13

CELANESE . . . TECHNICAL ANALYSIS

- Handling of Materials
- Time/Temperature/ Cooling
- Effects of Microgravity on Stretched Molecules



G14

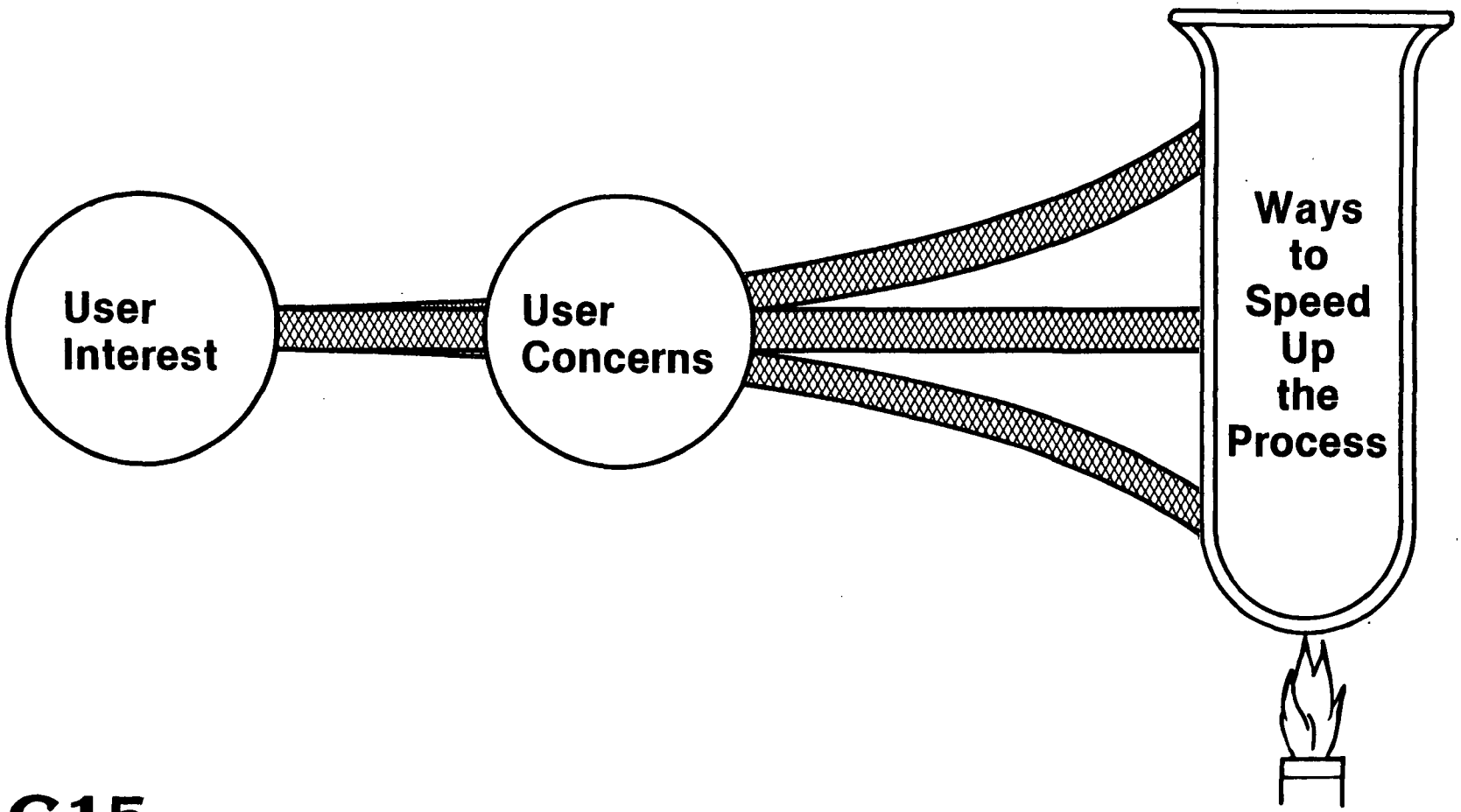
"WHAT WE HAVE LEARNED TO DATE"

We have completed two or more contacts with eight of the identified potential users and have drawn some general observations and conclusions from these discussions.

These observations may be summarized under three topic headings:

- Current user interest
- Current user concerns
- Ways to speed up the generation of user interest and, ultimately, user-sponsored development

WHAT WE HAVE LEARNED TO DATE



G15

WHAT WE HAVE LEARNED TO DATE - USER INTEREST

We have reached three general conclusions about user interest:

(1) Developing the basic relationship required to explore user interest is a multi-step, complex and time consuming process, necessarily involving all of the following steps:

- Initial contacts at levels where decisions can be made
- Follow up contacts to establish
  - the framework for controlled exchange of information
  - the range of business and technical areas to be explored
- Meetings to exchange concepts
- Follow up analyses to
  - validate feasibility of concepts
  - demonstrate commitment to support user needs
- Follow up meetings

(2) Once there is real user interest

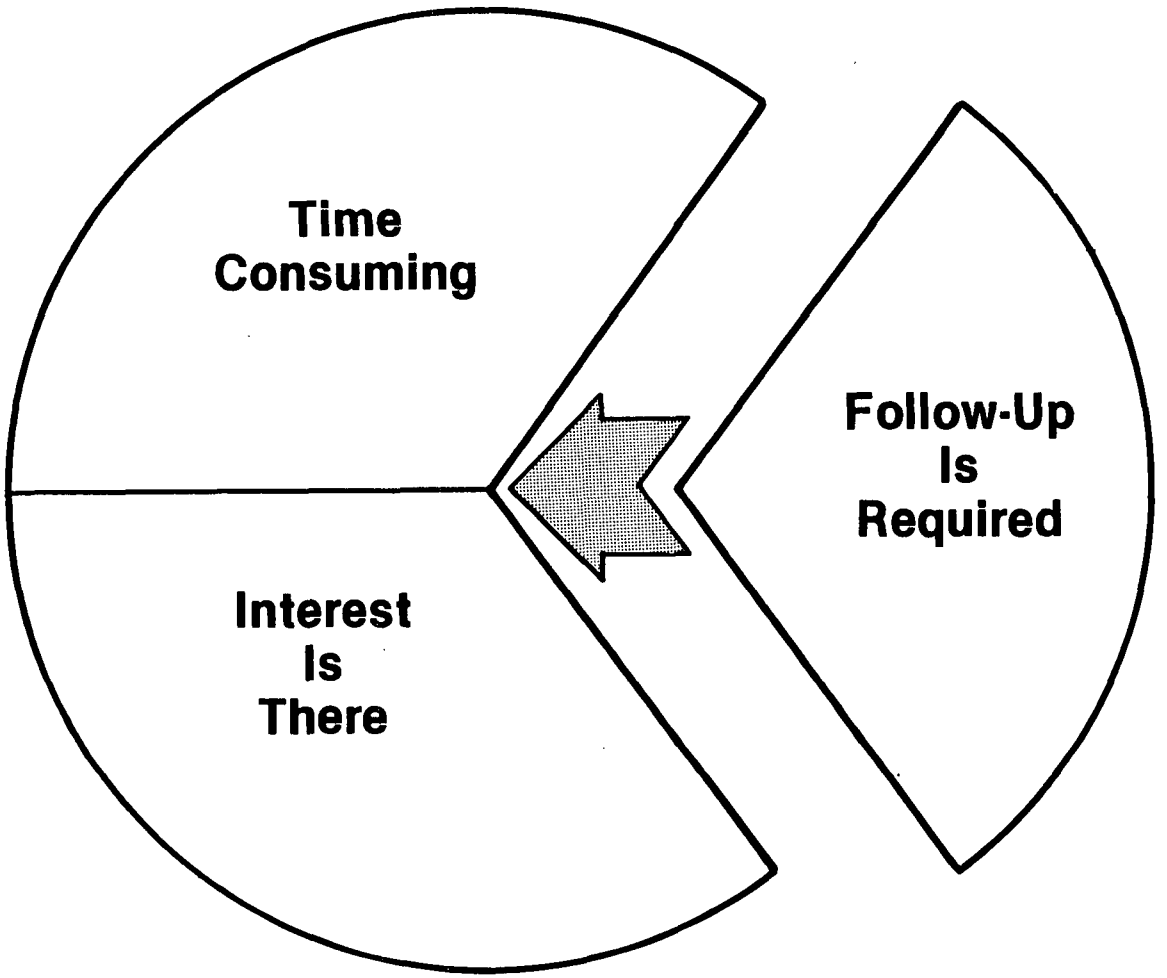
- Potential users will commit significant resources in establishing relationships, conducting meetings and following up
- An incubation period is required to develop product and process concepts of real value
- Users will wish to participate in the follow up studies of the conceptual ideas

(3) User interest must be nutured by continued exchanges involving:

- Technological analyses
- Additional contacts
- Information exchange

WHAT WE HAVE LEARNED TO DATE
— USER INTEREST —

VFX859



G16

WHAT WE HAVE LEARNED TO DATE - USER CONCERNS

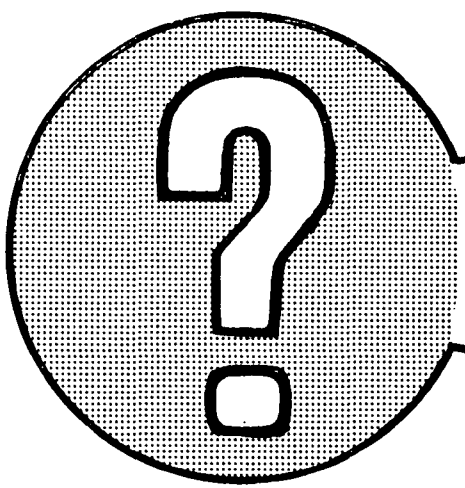
Potential users have expressed a number of concerns which interfere with user commitments to and support of programs -- These include

- The concern that intellectual property rights developed in the conceptualization, investigation and reduction to practice of processes and products cannot be safeguarded in a vehicle involving major government effort

- A question as to who will make the basic investment to develop and launch the vehicle which will support the enterprise which could arise from reduction of a concept to practice

- A need for assurance that the concept can be reduced to practice with use of in-house resources. Users are not interested in making significant out-of-pocket investments in others to do research or hardware development.

WHAT WE HAVE LEARNED TO DATE
– USER CONCERNS –



Intellectual Property Rights

Basic Investment

Out-of-Pocket Investment

G17

WHAT WE HAVE LEARNED TO DATE - SPEED UP THE PROCESS

We feel that there are ways for an initializing agency to improve communication with and improve the opportunity to identify, attract and maintain interested, committed commercial users -- These include:

- Development and institutionalization of buffered access techniques which assure user protection of proprietary interests in process, product and service concepts during identification, investigation, analysis and development

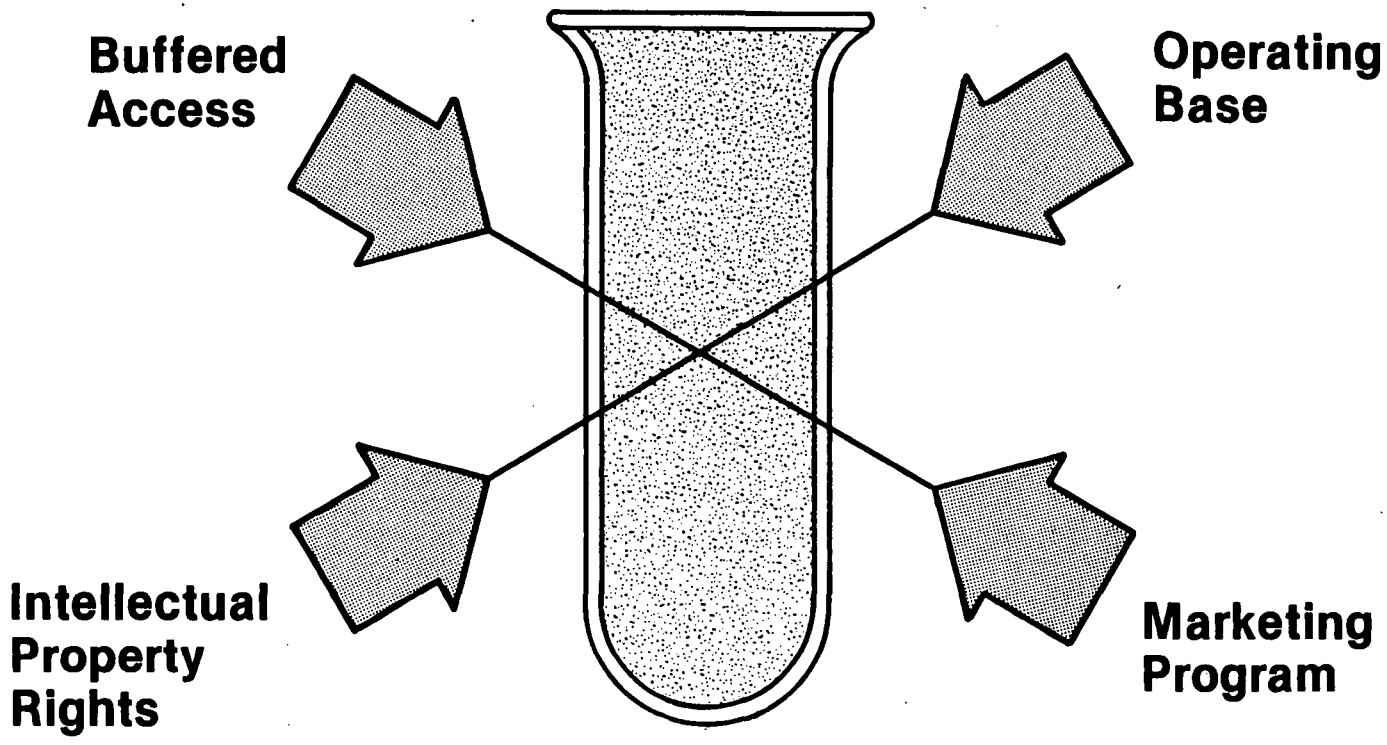
- Communication of commitments to protect intellectual property rights after the concept has been developed and is in practice

- Demonstration that there is a program to provide the operating base on which the final enterprise (mission) will be carried out

- Development and application of a formalized, ongoing marketing program which will provide support to the interested user and maintain a visible point of focus for stimulating and developing potential future users.

WHAT WE HAVE LEARNED TO DATE
– SPEED UP THE PROCESS –

VFX861



G18

MISSION REQUIREMENTS (TASK 1)

Technology Development Missions
Space Operations Missions
National Security Missions
Mission Requirements Summary

Dave Riel

TECHNOLOGY DEVELOPMENT MISSIONS

TECHNOLOGY DEVELOPMENT MISSIONS PROVIDE ON-ORBIT TESTING WHICH ENABLES:

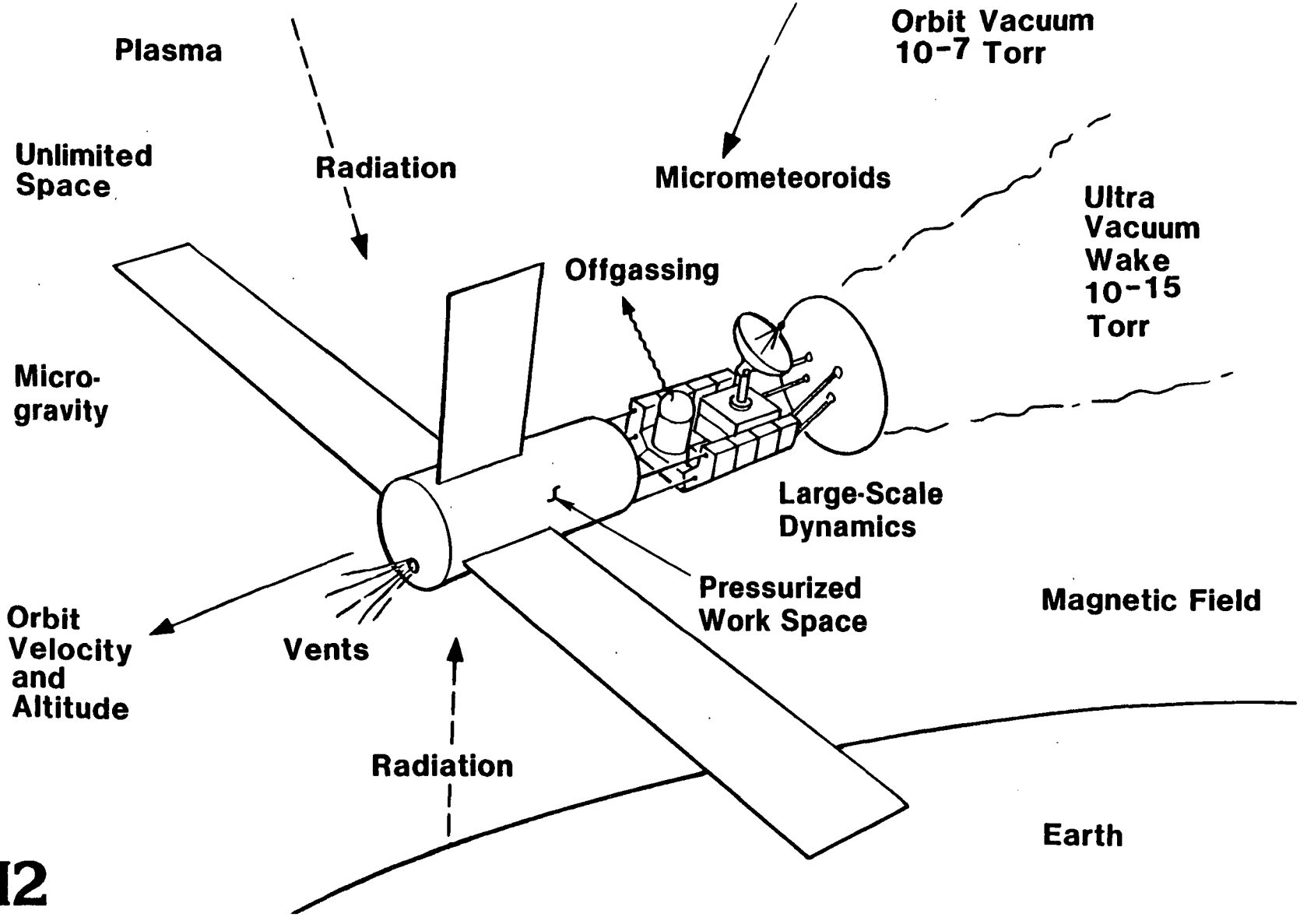
- Generic Mission and Payload Equipment for Future Applications

- Technology for Space Station Growth Applications

H1

SPACE STATION ENVIRONMENTAL TEST FACILITY

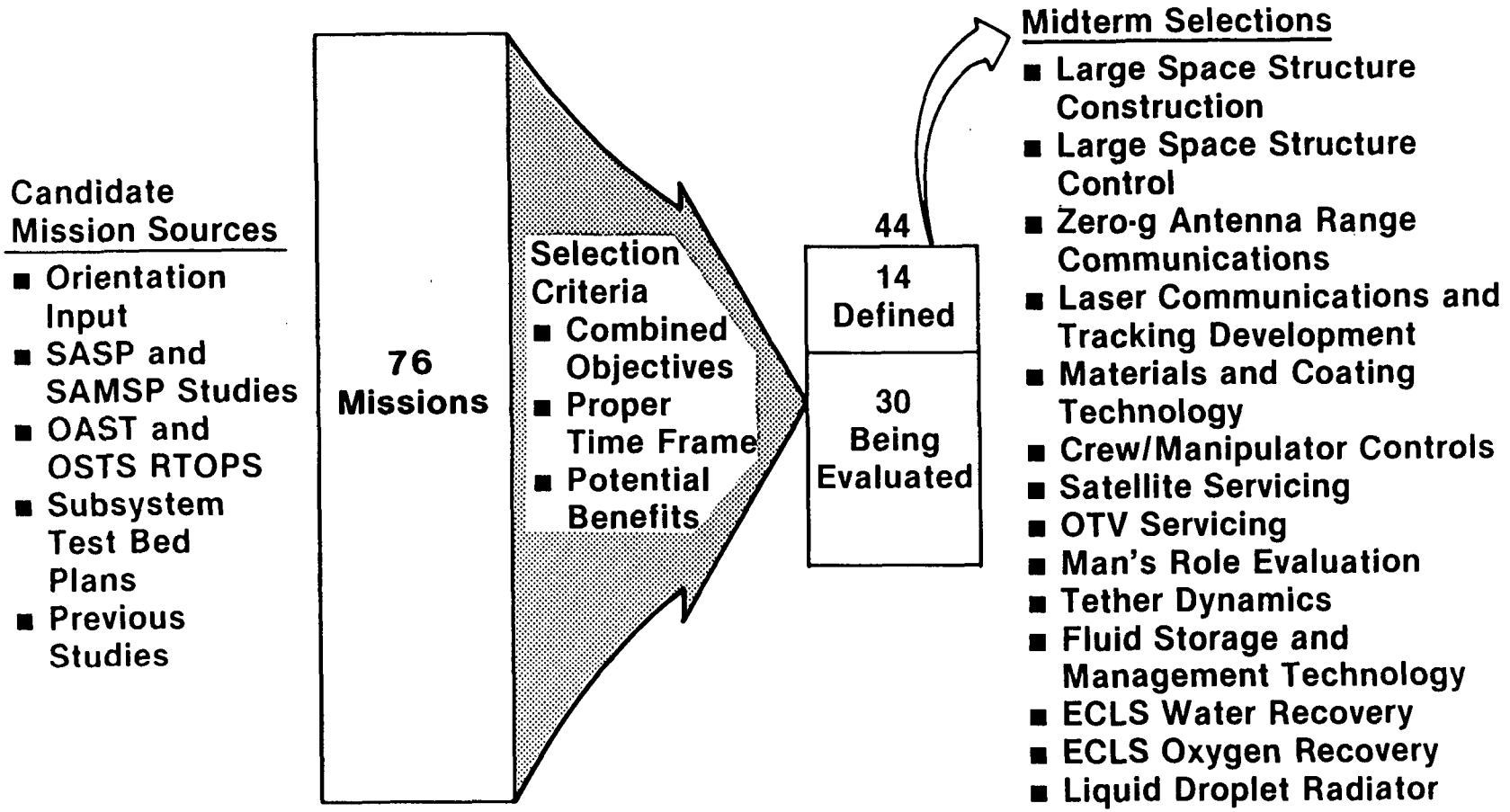
VFY026



H2

TECHNOLOGY DEVELOPMENT MISSION SELECTION

VFY084



H3

MISSION/ENVIRONMENT INTERACTION

MISSIONS \ ENVIRONMENTAL ATTRIBUTES	MICROGRAVITY	VACUUM	UNLIMITED SPACE	ORBIT ALTITUDE	ORBIT VELOCITY	MAGNETIC FIELD	PRESSURIZED VOLUME	LARGE-SCALE DYNAMICS	PLASMA	MICROMETEOROIDS	RADIATION	CONTAMINATION
LARGE SPACE STRUCTURE CONSTRUCTION	X	X	X					X				
LARGE SPACE STRUCTURE CONTROL	X	X	X					X				
ZERO-g ANTENNA RANGE COMMUNICATIONS		X		X								
LASER COMMUNICATIONS AND TRACKING		X	X								X	
MATERIALS AND COATINGS TECHNOLOGY		X			X				X	X	X	X
CREW/MANIPULATOR CONTROLS	X	X					X	X				
SATELLITE SERVICING	X	X					X	X				X
OTV SERVICING	X	X					X	X				
MAN'S ROLE EVALUATION	X	X	X				X	X			X	X
TETHER DYNAMICS	X	X				X		X	X		X	X
FLUID STORAGE AND MANAGEMENT	X	X										
ECLS WATER RECOVERY	X						X					
ECLS OXYGEN RECOVERY	X						X					
LIQUID DROPLET RADIATOR	X	X	X					X	X		X	X

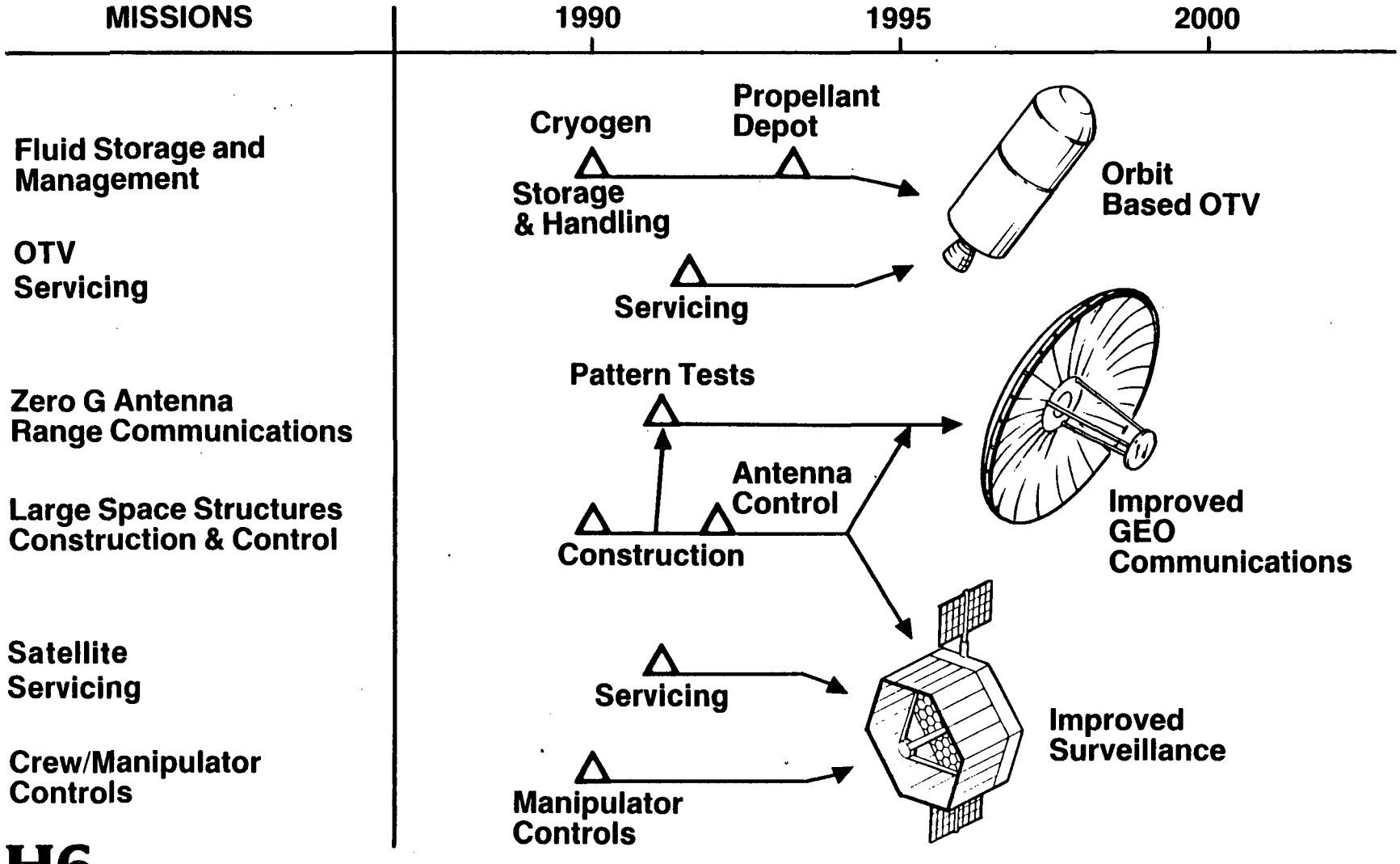
H4

GENERIC PAYLOAD DEVELOPMENT

MISSION	FUNCTIONAL VALUE	POTENTIAL USE	MISSION CATEGORY
• LARGE SPACE STRUCTURES CONSTRUCTION AND CONTROL	• HIGH-RESOLUTION ANTENNAS AND MIRRORS	• EARTH OBSERVATION • ASTRONOMY • SURVEILLANCE • COMMUNICATIONS	• SCIENCE AND APPLICATIONS • NATIONAL SECURITY • COMMERCIAL
• ZERO-g ANTENNA RANGE COMMUNICATIONS	• IMPROVED DIRECTIONALITY AND ISOLATION	• COMMUNICATIONS	• COMMERCIAL • NATIONAL SECURITY
• LASER COMMUNICATIONS AND TRACKING	• HIGHER DATA RATES • NARROW BEAM TRANSMISSION	• EARTH OBSERVATION • COMMUNICATIONS • SURVEILLANCE • SPACE STATION COMMUNICATIONS	• SCIENCE AND APPLICATIONS • COMMERCIAL • NATIONAL SECURITY • SPACE OPERATIONS
• CREW MANIPULATOR CONTROLS • SATELLITE SERVICING • OTV SERVICING	• IMPROVED SPACE ROBOTICS • REDUCED MISSION COST	• SATELLITE SERVICE • OTV SERVICE	• ALL MISSION CATEGORIES
• FLUID STORAGE AND MANAGEMENT TECHNOLOGY	• IMPROVED ON-ORBIT TRANSFER VEHICLES • REDUCED STS FLIGHTS	• ON ORBIT DEPOT	• SPACE OPERATIONS

H5

POTENTIAL HIGH VALUE MISSIONS



H6

VFX977

GROWTH SPACE STATION IMPROVEMENTS

Subsystem	Technology Development Mission	Major Benefit Areas: Initial Weight	Resupply Weight	Cost	Performance	Security
ECLS	O_2 Recovery		▲	▲		
	Water Recovery		▲	▲		
CDMS	Laser Communications and Tracking				▲	▲
Thermal Control	Liquid Droplet Radiator	▲			▲	
	Material and Coating Technology	▲			▲	
ACS	Large Space Structure Control				▲	
	Tether Thrust and Drag Control		▲		▲	
Crew Systems	Man's Role Evaluation			▲	▲	

H7

TECHNOLOGY DEVELOPMENT MISSION MIDTERM CONCLUSIONS

VFY021

Technology Development Missions:

- **Utilize the Unique Space Station Environment**
- **Enable:**
  - **— Advanced Mission Technology**
  - **— Increased Space Station Capability**

Advanced Missions

More Mission Capacity

- **Provide Benefits to All Categories of Users**
- **Require Manned Participation For the Majority**
- **Are Relatively Short Term and Orbit Independent**
- **Require Exterior Volume — 15 Pallets (Equiv)**

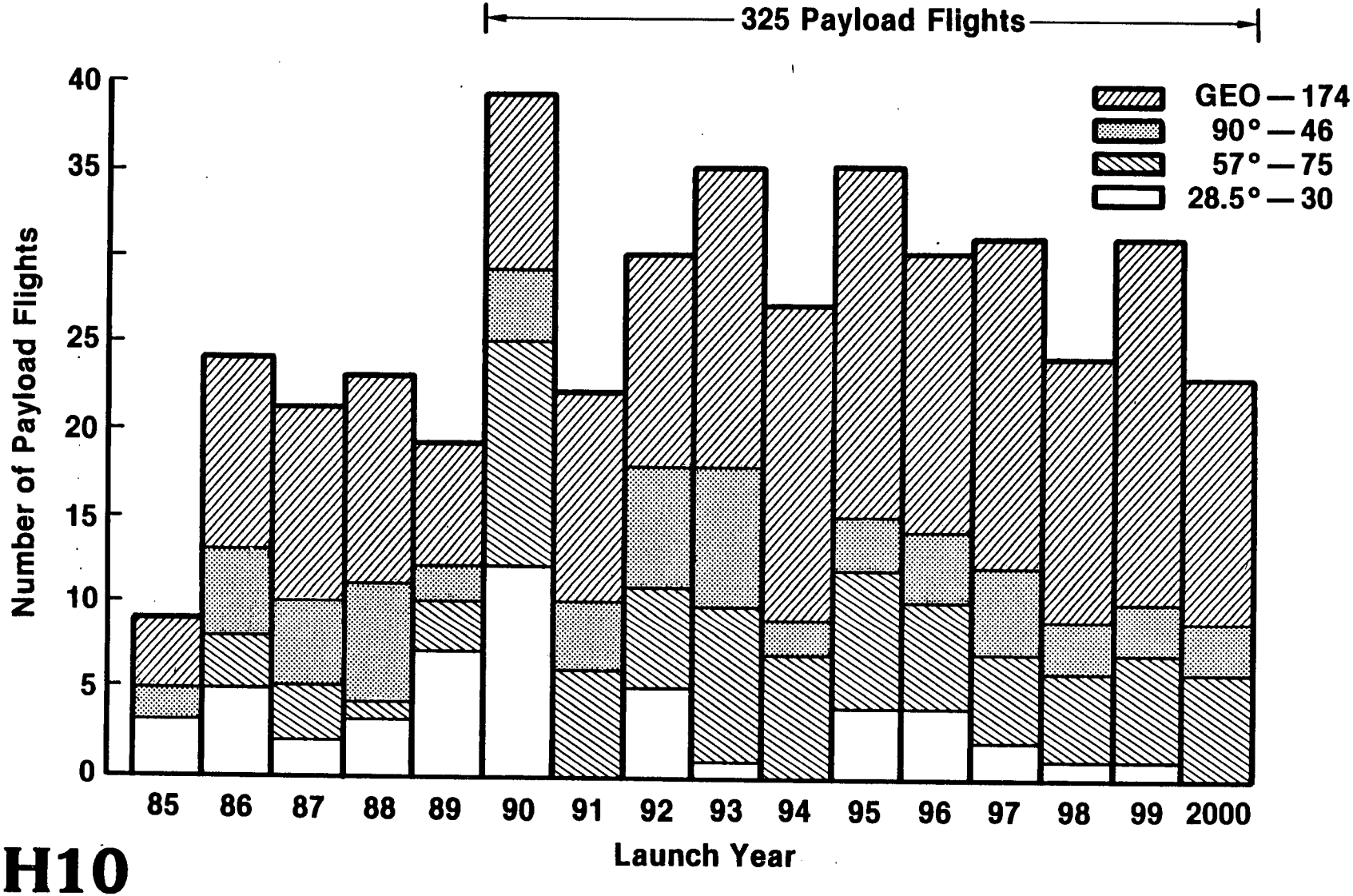
H8

SPACE OPERATIONS MISSIONS

- Transportation (OTV, TMS, Other)
  - — Deploy/Retrieve
  - — Debris Collection
- Assembly, Integration, Checkout
  - — Large Structures
  - — Stage/Payload Mating
- Service
  - — Maintain/Repair/Resupply
  - — Instrument Reconfiguration
- Storage
  - — Propellants (Cryo, Storables)
  - — Spares
  - — Payloads
- Space Utilization
  - — Quarantine
  - — Rescue

H9

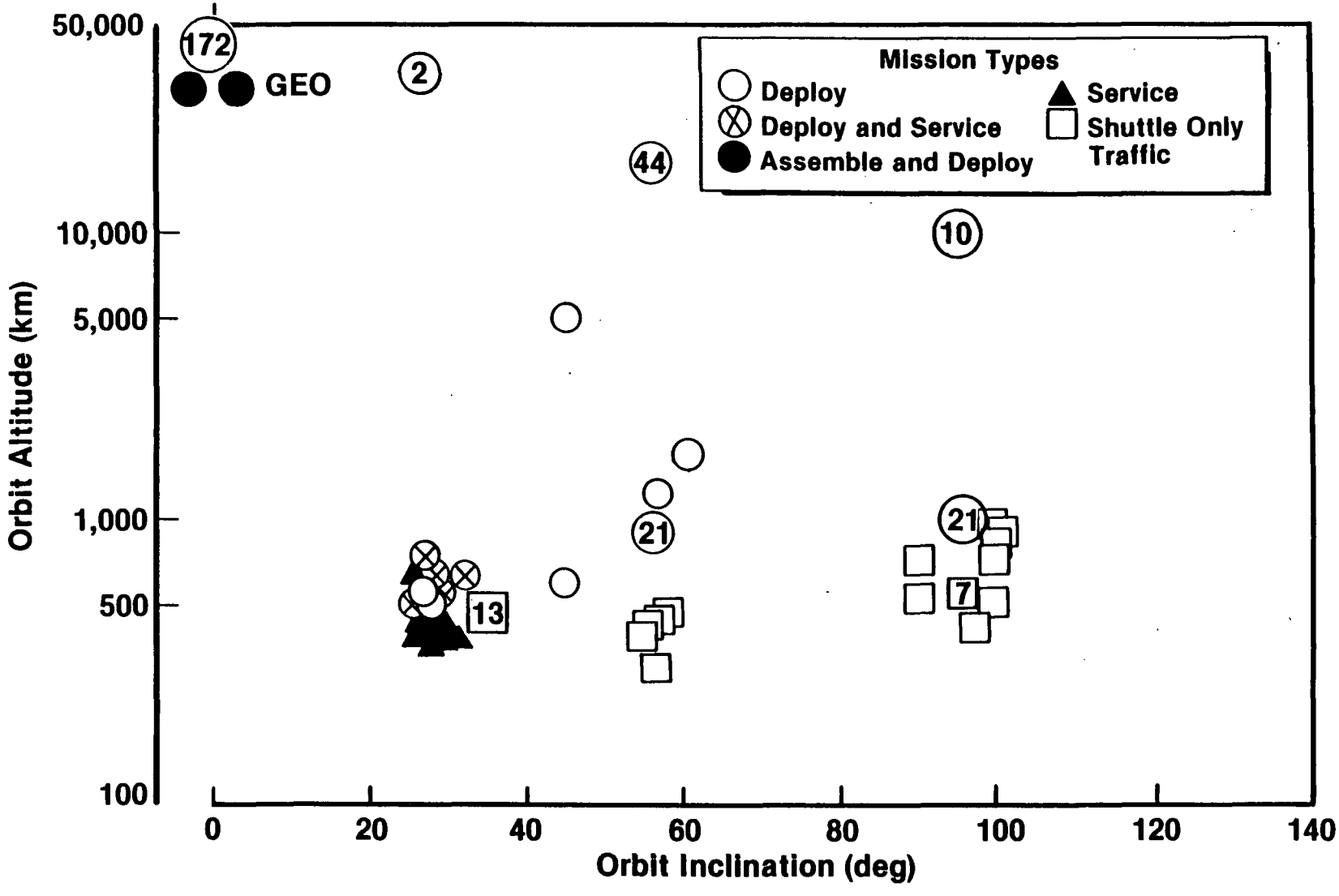
SPACE OPERATIONS MISSION MODEL



H10

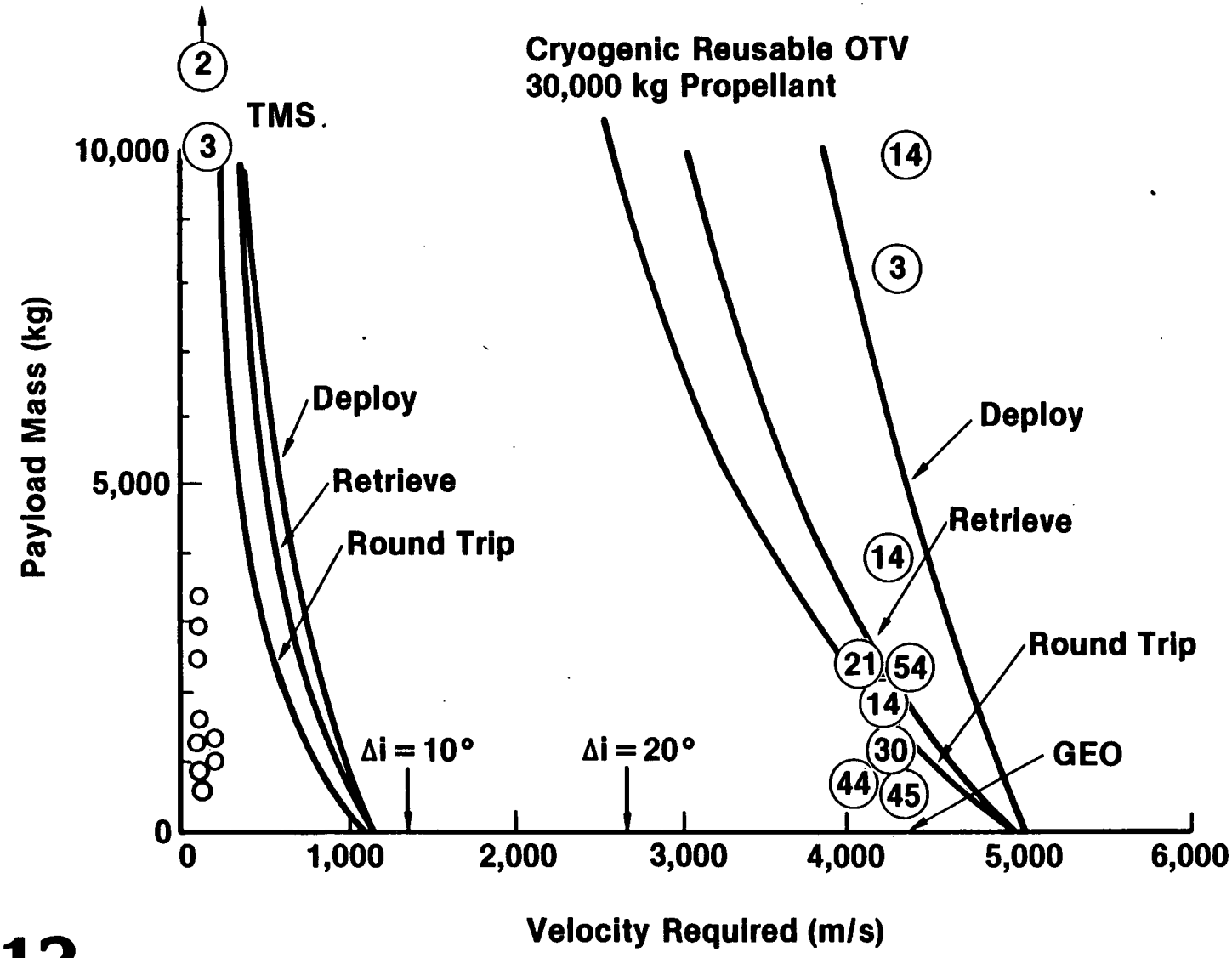
VFX995

SPACE OPERATIONS MISSIONS
1990-2000



H11

ORBIT TRANSFER VEHICLE CAPABILITY

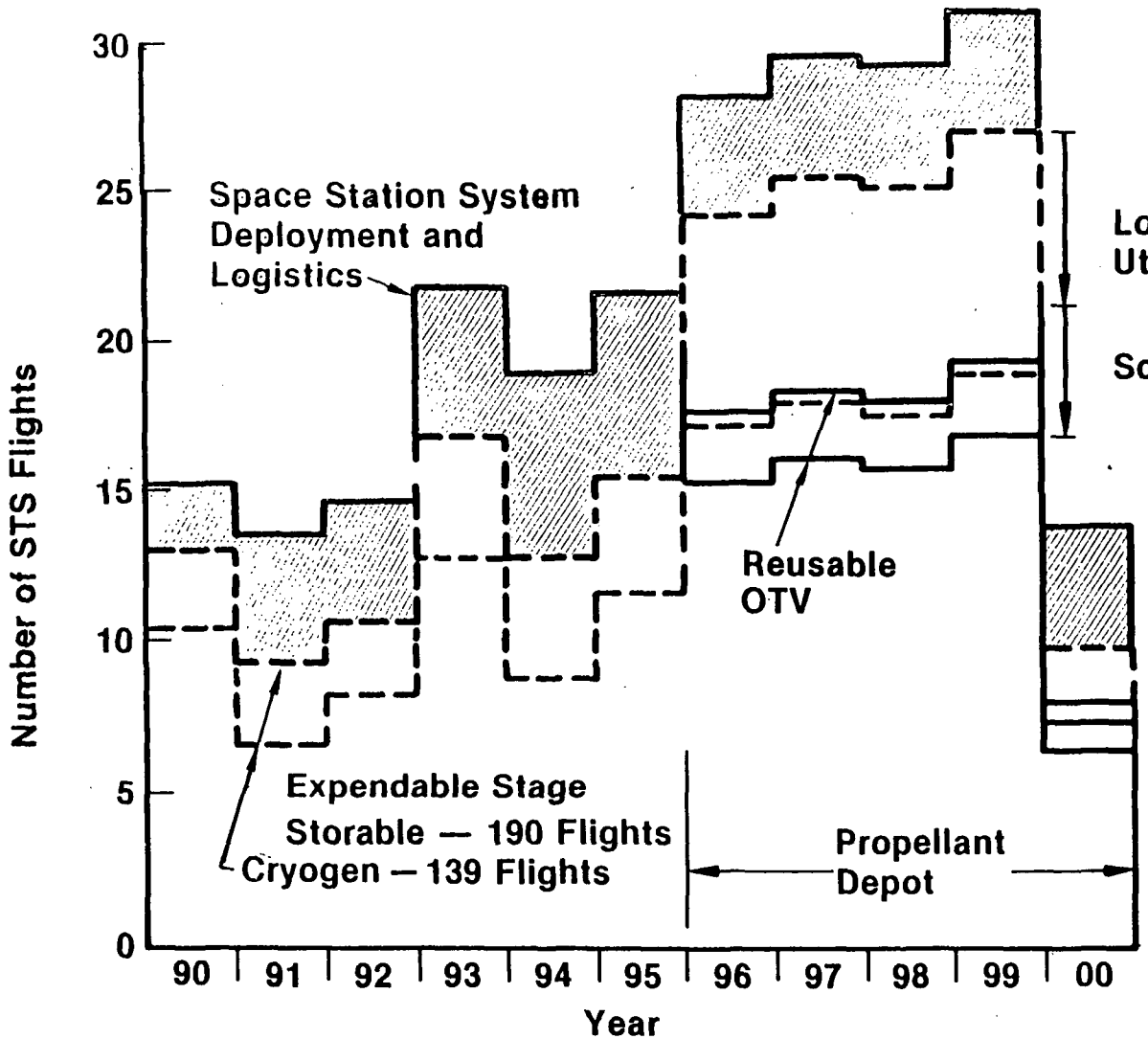


H12

STS FLIGHT REQUIREMENTS

VFX979

REUSABLE OTV AND DEPOT EFFECTS



	Flight Savings
Load Factor Utilization	31
Scavenging	10
ROTV Savings	
Over Storable	41
Over Cryogen	9

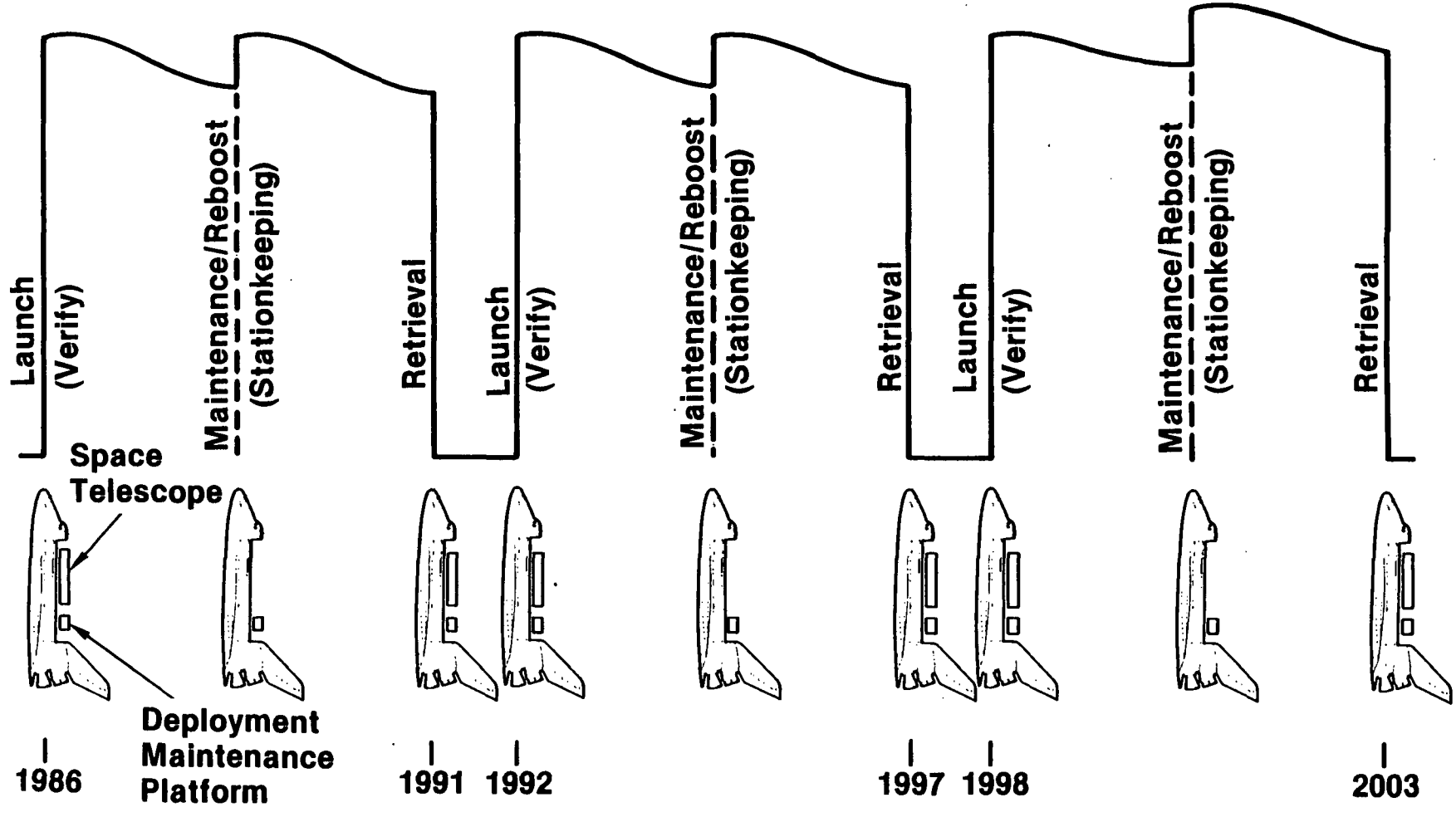
H13

SPACE OPERATIONS ISSUES

- Traffic Model Validation
- Shuttle Fleet Size
- Shuttle Utilization Factor
- Upper Stage Program Development
- Cryogen Scavenging Feasibility
- Orbital Propellant Depot Cost

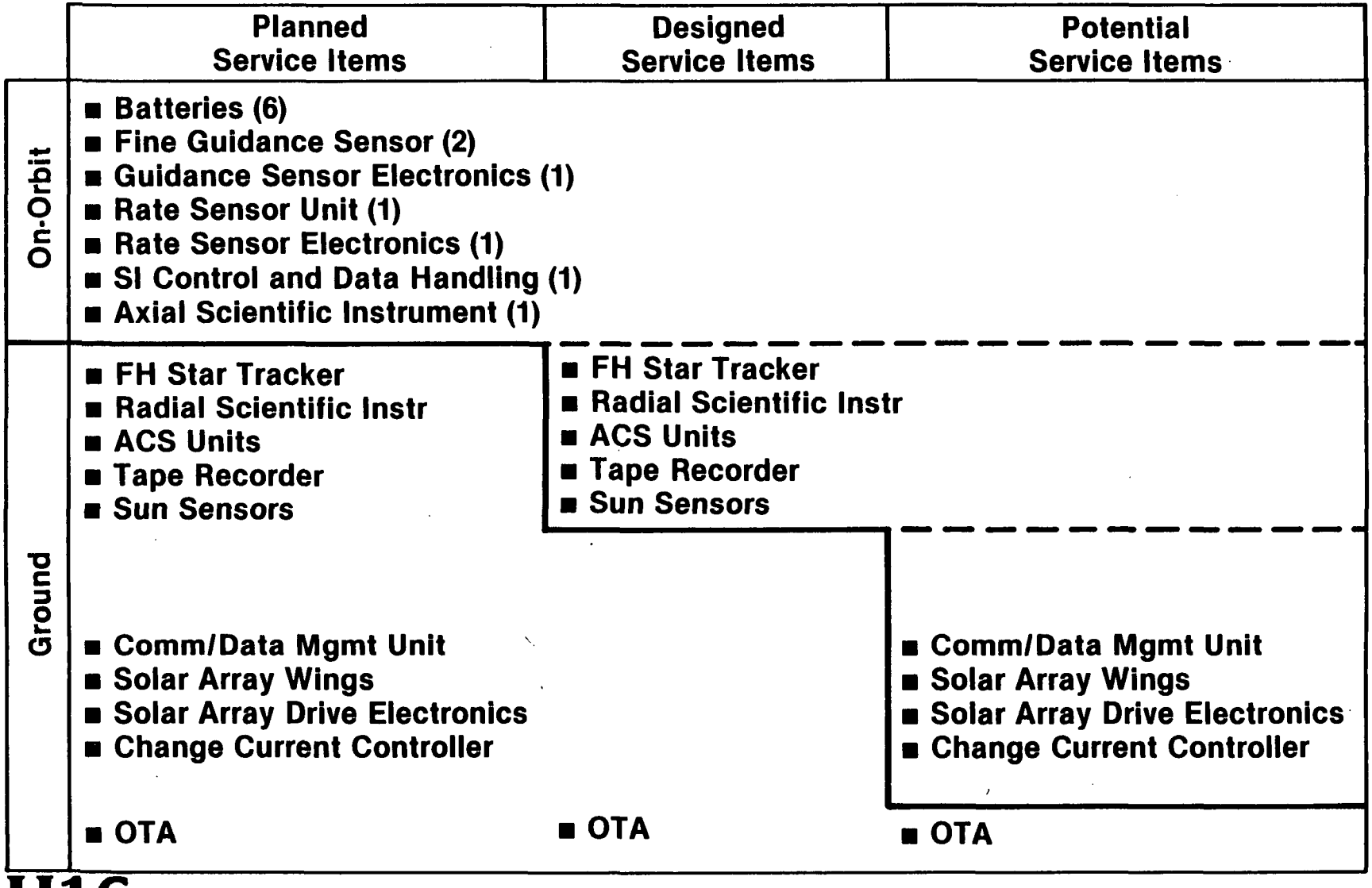
H14

SPACE TELESCOPE MAINTENANCE



H15

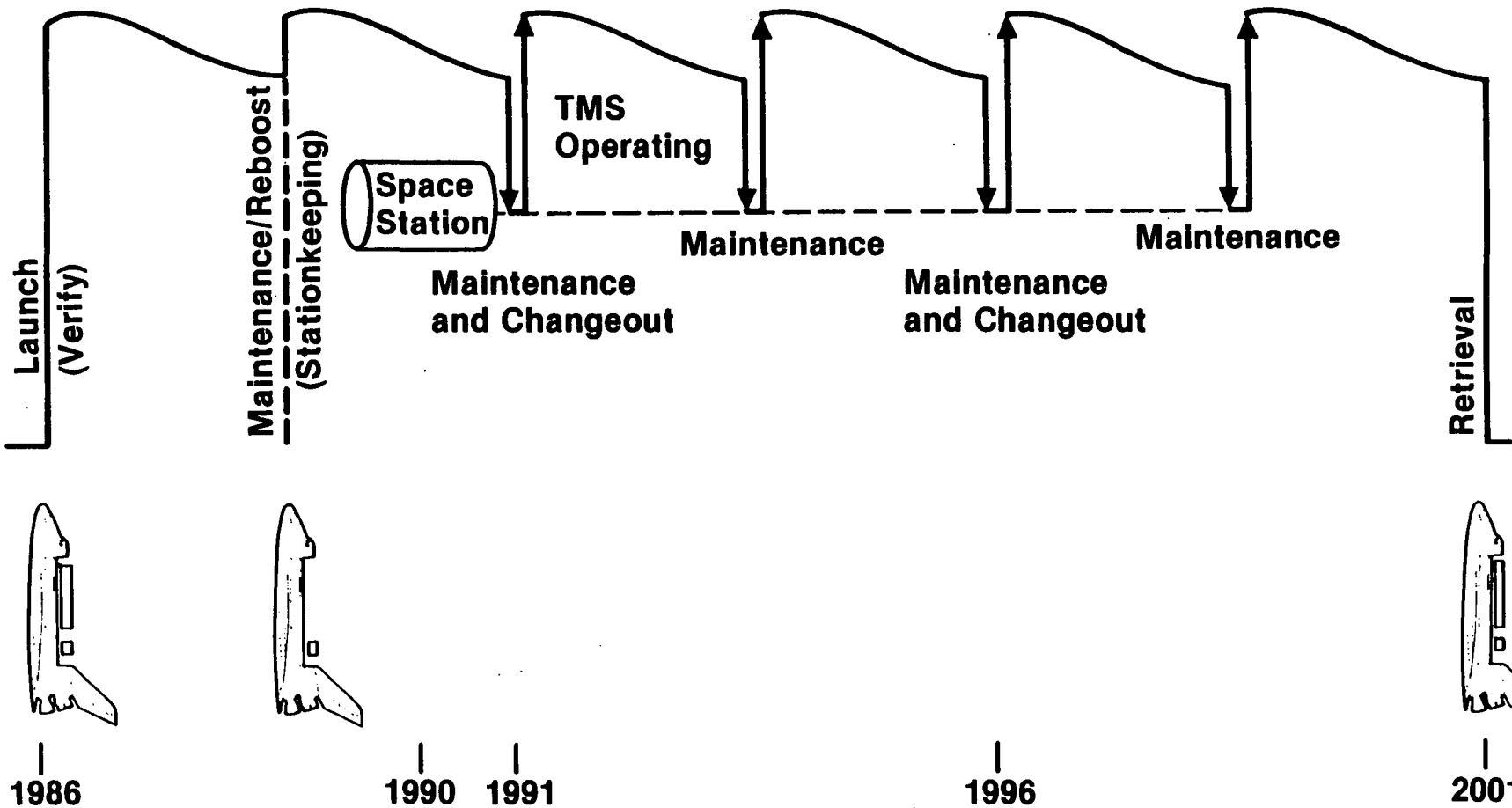
SPACE TELESCOPE MAINTENANCE



H16

SPACE TELESCOPE MAINTENANCE SPACE STATION

VFX819

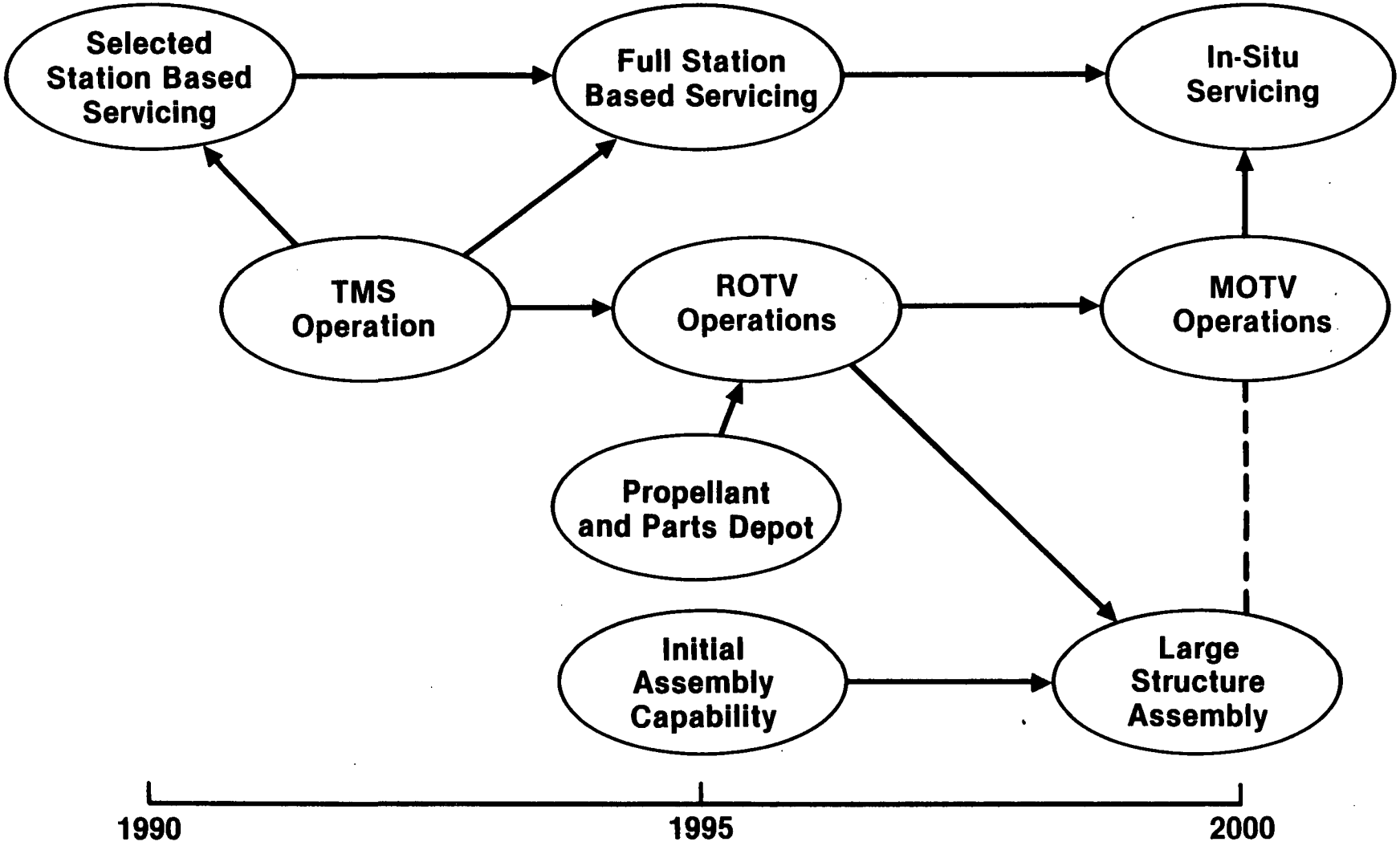


- Orbiter Requires DMP

H17

REQUIRED SPACE OPERATIONS CAPABILITIES

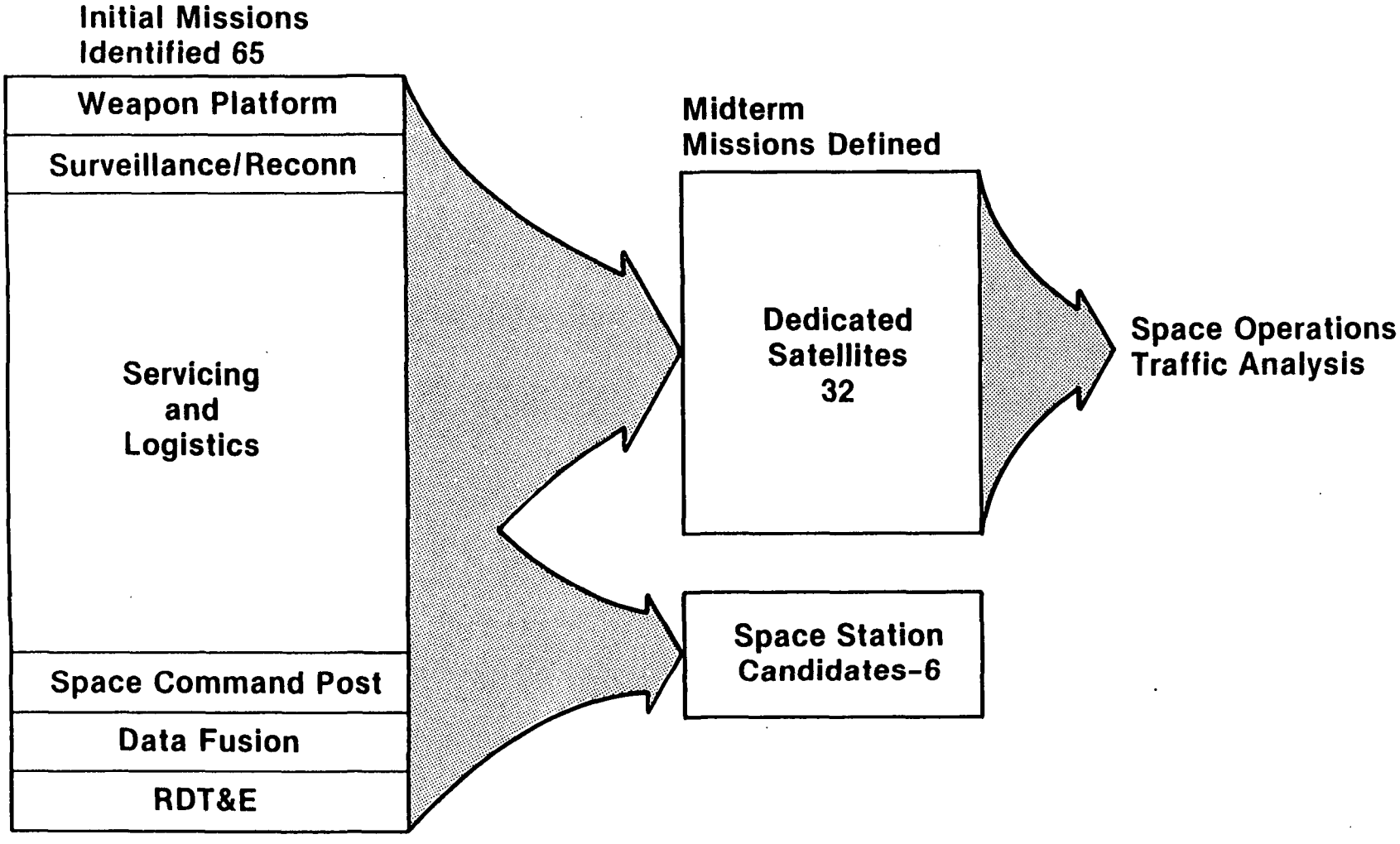
VFY019



H18

NATIONAL SECURITY MISSIONS

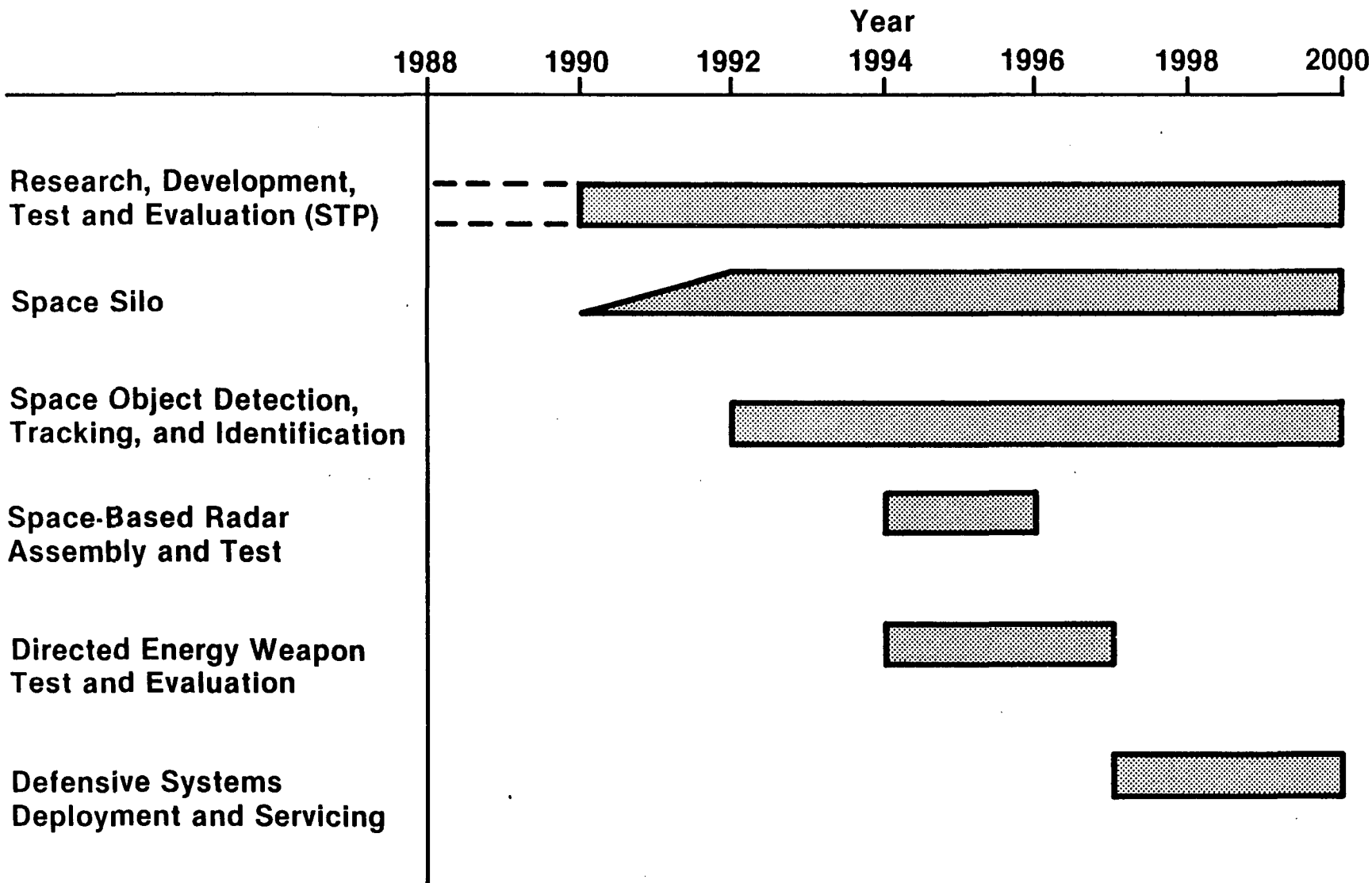
VFX972



H19

NATIONAL SECURITY MISSIONS
MIDTERM

VFY144



H20

NATIONAL SECURITY MISSION REQUIREMENTS

VFY018

	INITIAL	ULTIMATE
Orbit	28.5° Initial	Polar
Facilities (Equiv)	2 Modules 2 Pallets	3 Modules 4 Pallets
Crew	1-2	2-5
Power	3 kW	10 kW

H21

NATIONAL SECURITY MISSIONS MIDTERM CONCLUSIONS

- Minimal Influence on Overall Requirements
- Prime Continuing Missions Are RDT&E
  - — Additional Duration, Power, and Crew
  - — Reduced Support System Requirements
- Space Station Enhances Current Capabilities
  - — Reduced Satellite Response/Replacement Time
  - — Enhanced Space System Survivability/Endurance
- Space Station Offers New Mission Capabilities
  - — Low-Cost Space Sensor Base
  - — Orbital Assembly of Large Structures
  - — Potential Depot Advantages

H22

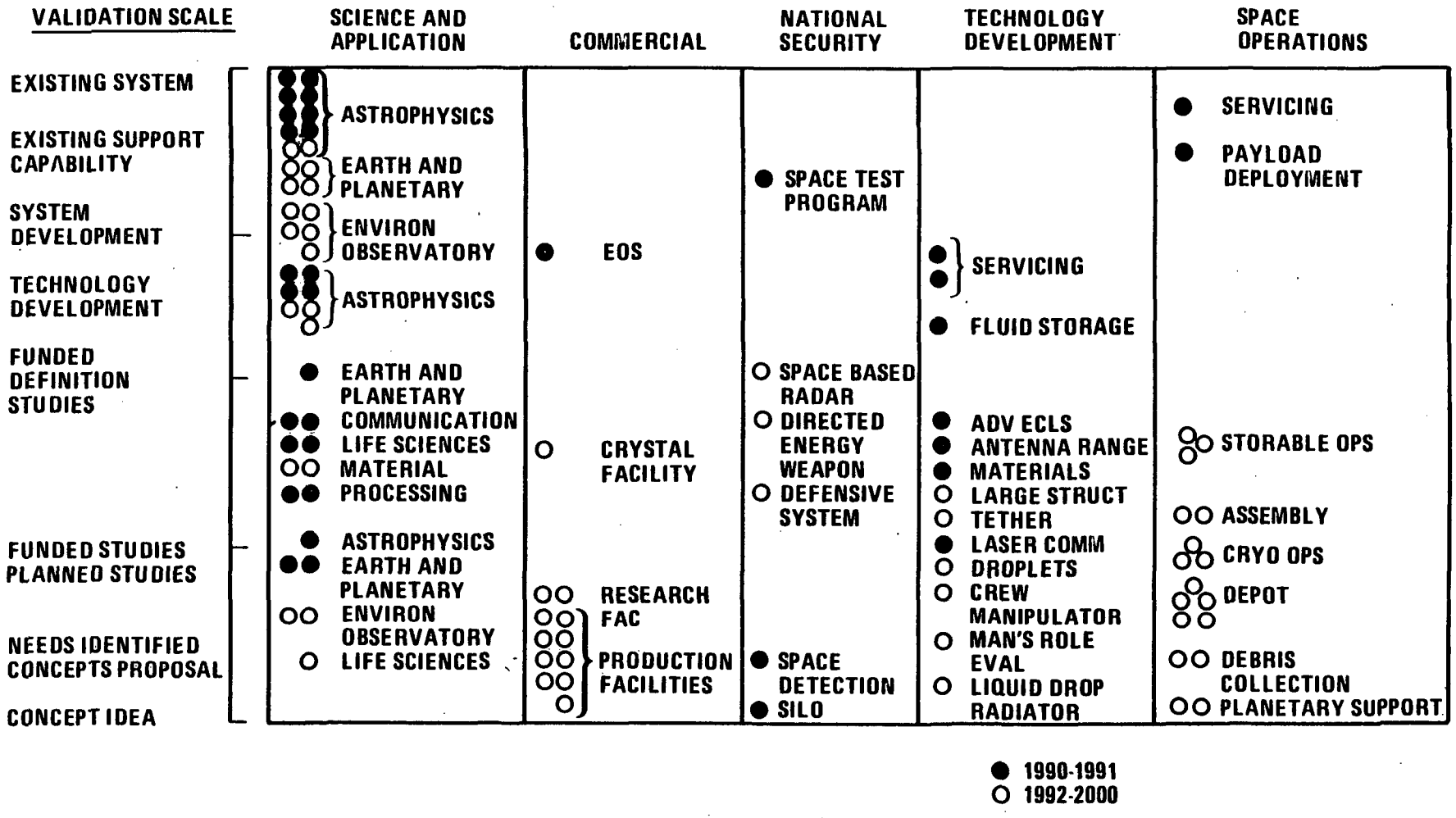
MISSION REQUIREMENTS SUMMARY

Dave Riel

MIDTERM MISSION SET — 95 TOTAL

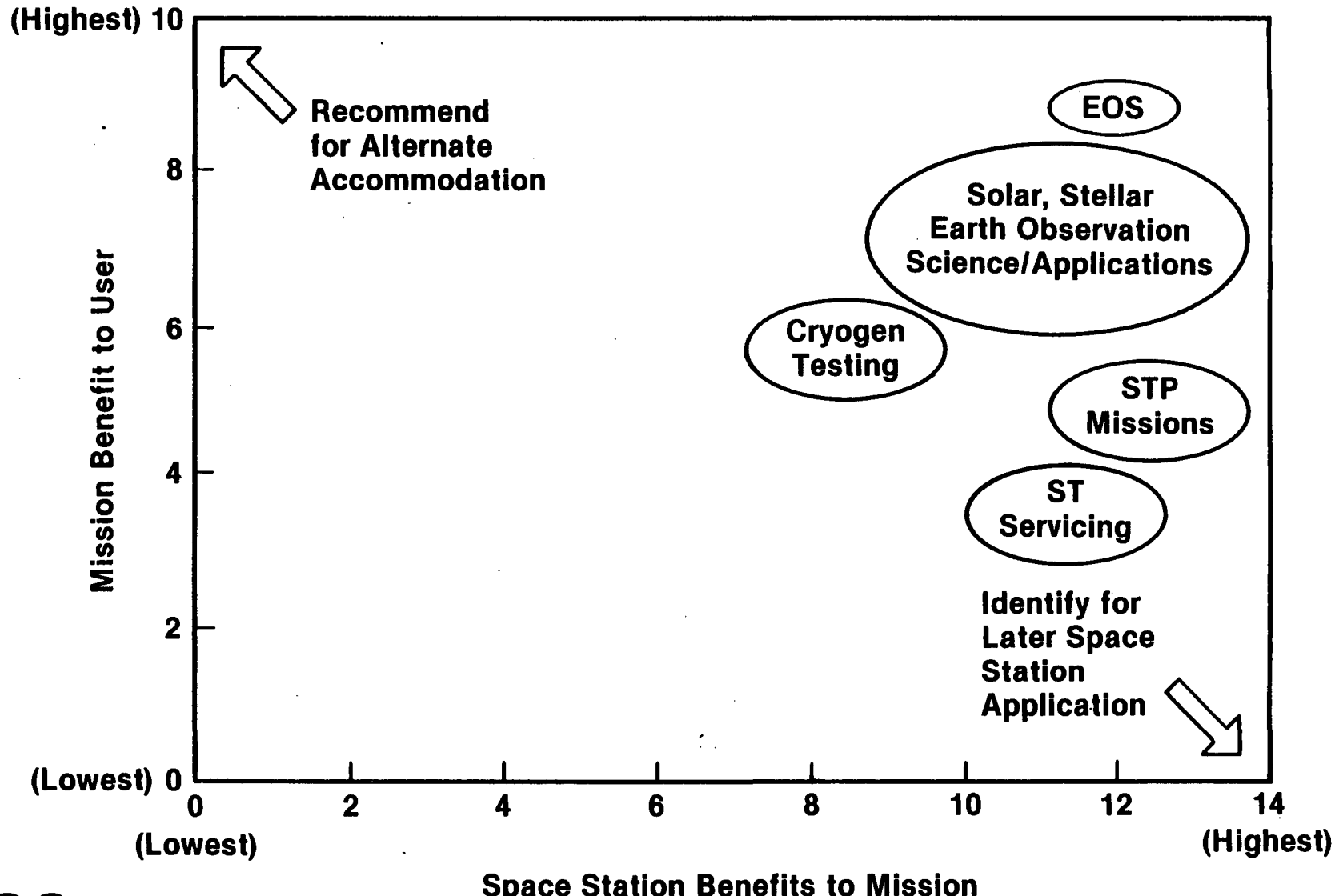
CODE	NAME	DATE	DUR	INC DEG	INC MAX	INC MIN	ALT KM	ALT MAX	ALT MIN	STAT PLAT	SER	NO CR	HRS DAY	POWER W	MASS KG	G
SAS001	SOLAR OPT TELE	88	1	33	57	28	400	435	370	R		1.00	4	5000	8175	0
SAS002	SIRTF	89	10	28	57	0	400	430	350	R		1.00	4	1045	8103	0
SAS003	STARLAB	90	1	28	57	20	400	800	350	R		1.00	4	2220	3280	0
SAS004	COMP SPEC COSRAY NUC	94	2	57	57	28	400	435	370	R		1.00	8	731	3082	0
SAS005	SOL SOFT XRAY TS	88	5	57	98	28	430	600	350	D	A M	1.00	2	240	1300	0
SAS006	SOLAR TERR OBS	93	2	57	57	57	400	350	600	D	A L	1.00	8	3000	16559	0
SAS007	PINHOLE XRAY	91	1	97	97	80	370	800	350	R		1.00	8	0	10000	0
SAS008	XRAY OBSER	92	2	28	57	0	400	370	370	A	A	1.00	2	900	1668	0
SAS009	SPACE TELESC	85	15	28	28	28	600	600	600		M	3.00	8	2100	1000	0
SAS010	HIRES X&G-RAY SPEC	90	2	28	45	0	400	500	350	A	A M	1.00	2	530	2600	0
SAS011	XRAY TIMING EXPL	88	2	28	57	0	400	600	300		A M	1.00	4	600	11000	0
SAS012	SOLAR INT DYNAMICS	91	5	28	28	28	575	575	575		M	2.00	8	800	9516	0
SAS013	ADV XRAY ASTROFAC	91	10	28	57	0	500	600	400		A	1.00	4	2000	1354	0
SAS014	LAMAR	92	6	28	57	0	400	435	200		A M	1.00	2	3400	20500	0
SAS015	VLBI	93	3	28	57	28	400	600	350		A B	2.00	8	900		
SAS016	LRG AMB DEPL IRTSC	93	10	28	50	28	700	800	400		M	3.00	8	3000		
SAS017	ADV SOLAR OBSR	93	5	57	57	0	400	600	350	A	A	1.00	4	1095	0	0
[illegible]	[illegible]	[illegible]						95	1	28	57	28	700	700	450	K	50	0
[illegible]	[illegible]	[illegible]						[illegible]				K			3	1000	250	0
TGN001	LSS CONTR EXP	92	1	28	90	0	400	999	300	R		1.00	1	1000	600	0
TGN002	ZERO G ANT RANGE	90	1	28	90	28	400	999	300	R		2.00	8	1000	9000	0
TGN003	MATERIALS&COAT TECH	90	5	28	97	28	400	600	300		D M	1.00	2	0	200	0
TGN004	TETHER DYNAMICS	92	1	28	97	0	400	600	300	R		1.00	2	1000	0	0
TGN005	LRG STRUCT CONSTR	92	1	28	57	28	400	999	350	R		2.00	8	500	0	0
TGN006	FLUID STORE&MANAG	90	1	28	97	28	400	999	300	R		1.00	4	500		
TGN007	LIQUID DROPLET RAD	92	1	28	97	0	400	999	350	R		1.00	4	200		
TOP001	SATELL SERV TECH	90	99	28	90	28	400	999	300	R		2.00	8	0		
H24	TV SERVICE TECH	90	1	28	90	28	400	999	300	R		2.00	4	1500		

RELATIVE MISSION VALIDATION



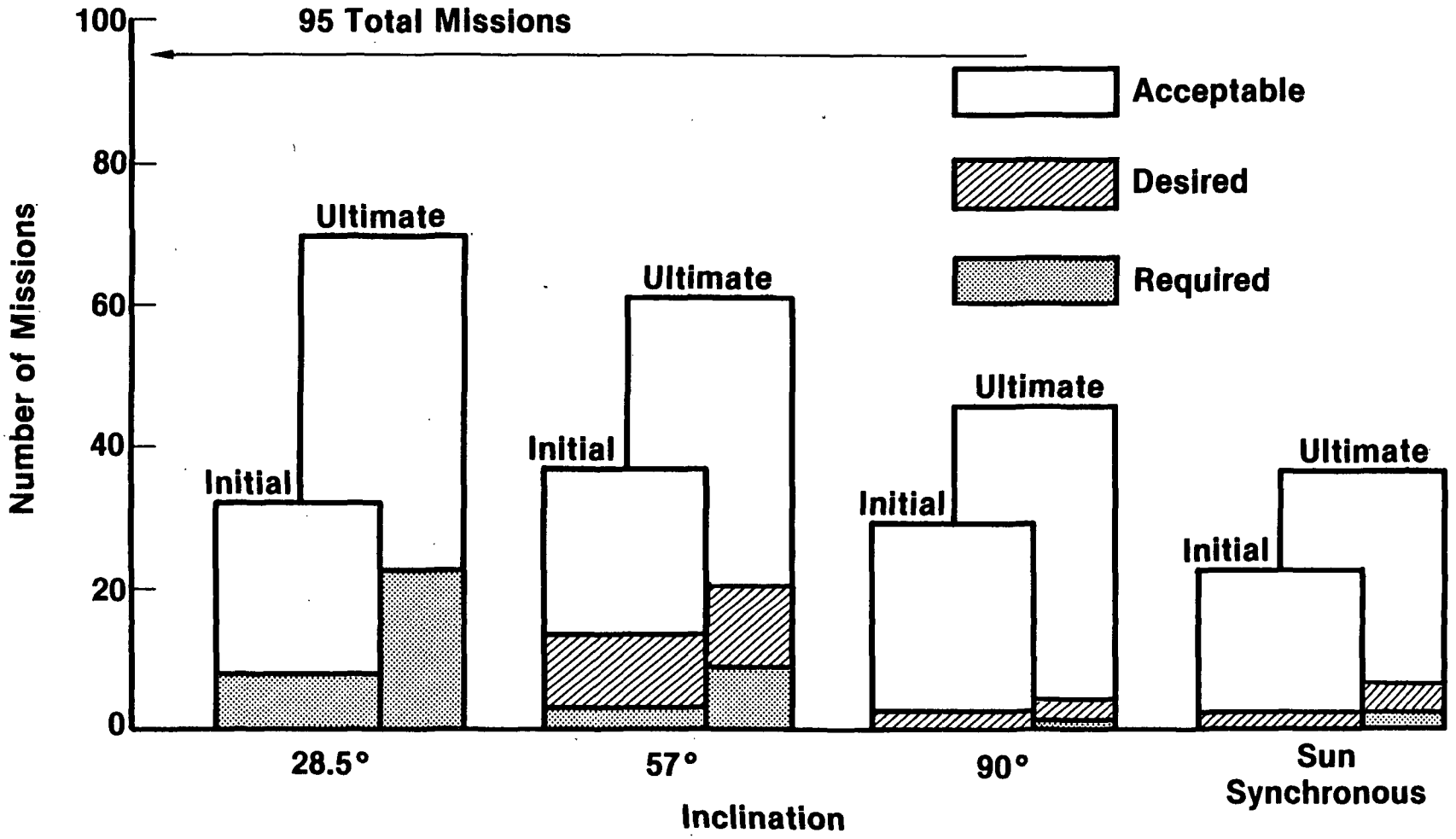
H25

MISSION PRIORITY



H26

MISSION INCLINATION DISTRIBUTION

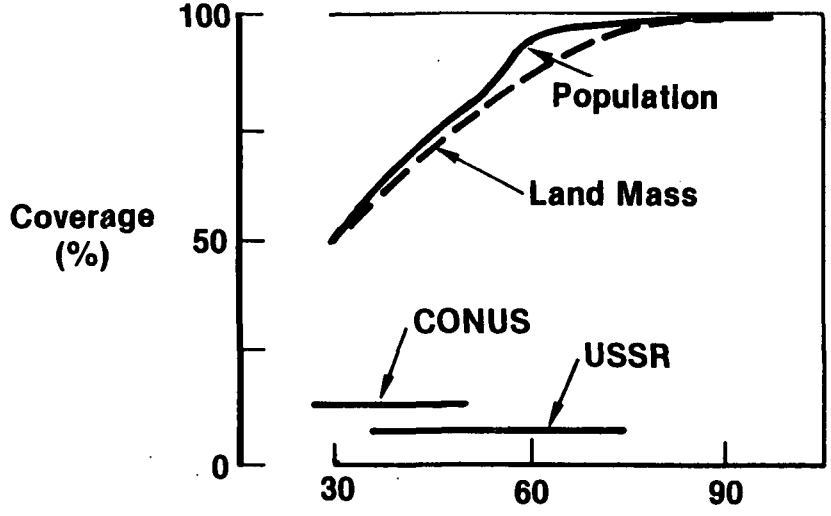


H27

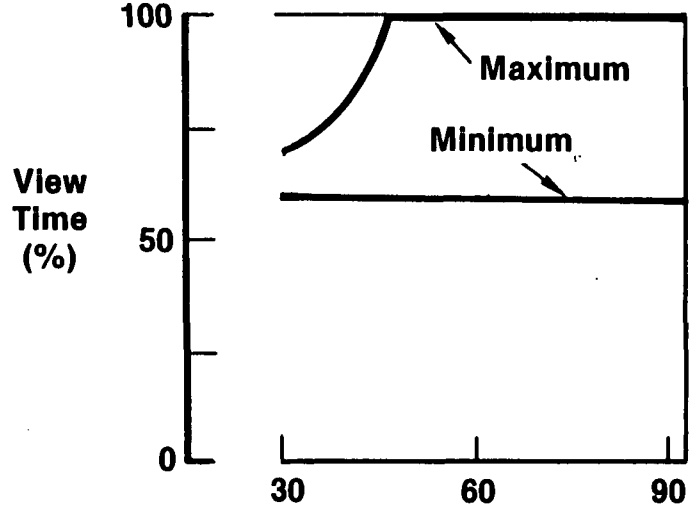
ORBIT INCLINATION SENSITIVITIES

VFX823

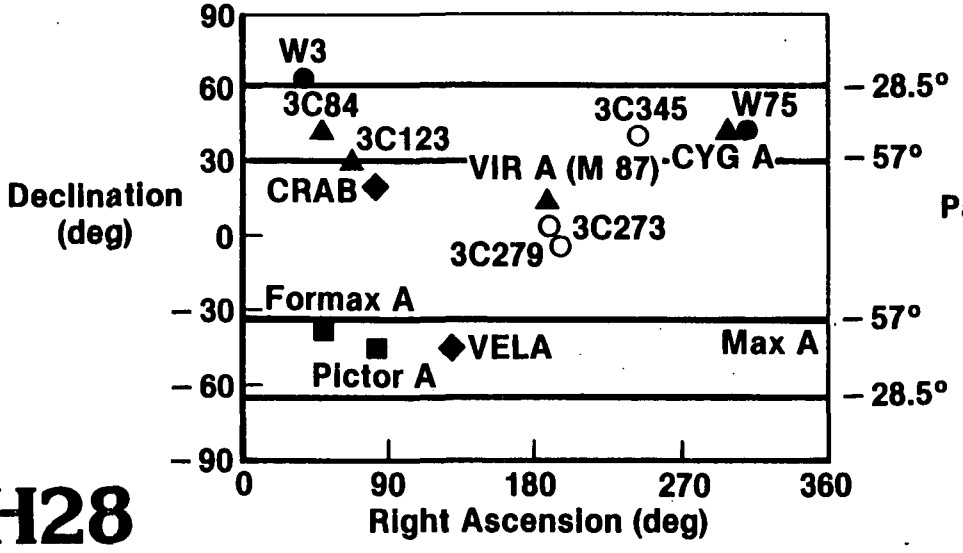
EARTH OBSERVATIONS



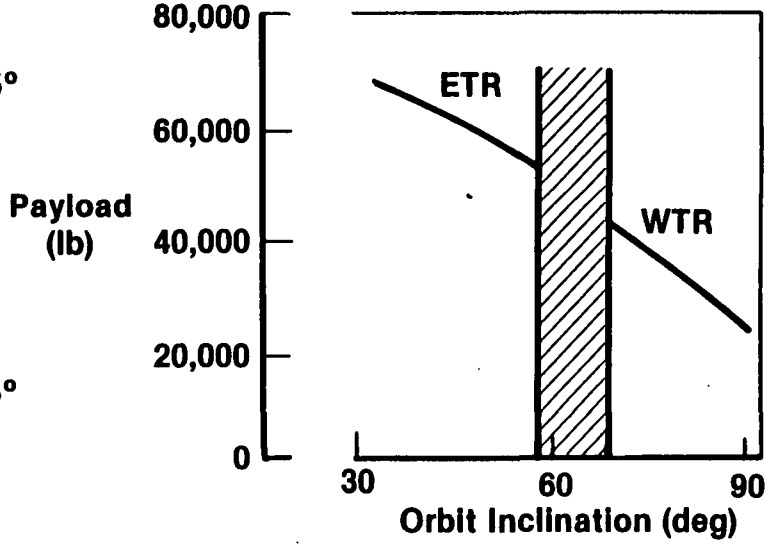
SOLAR VIEWING



STELLAR VIEWING



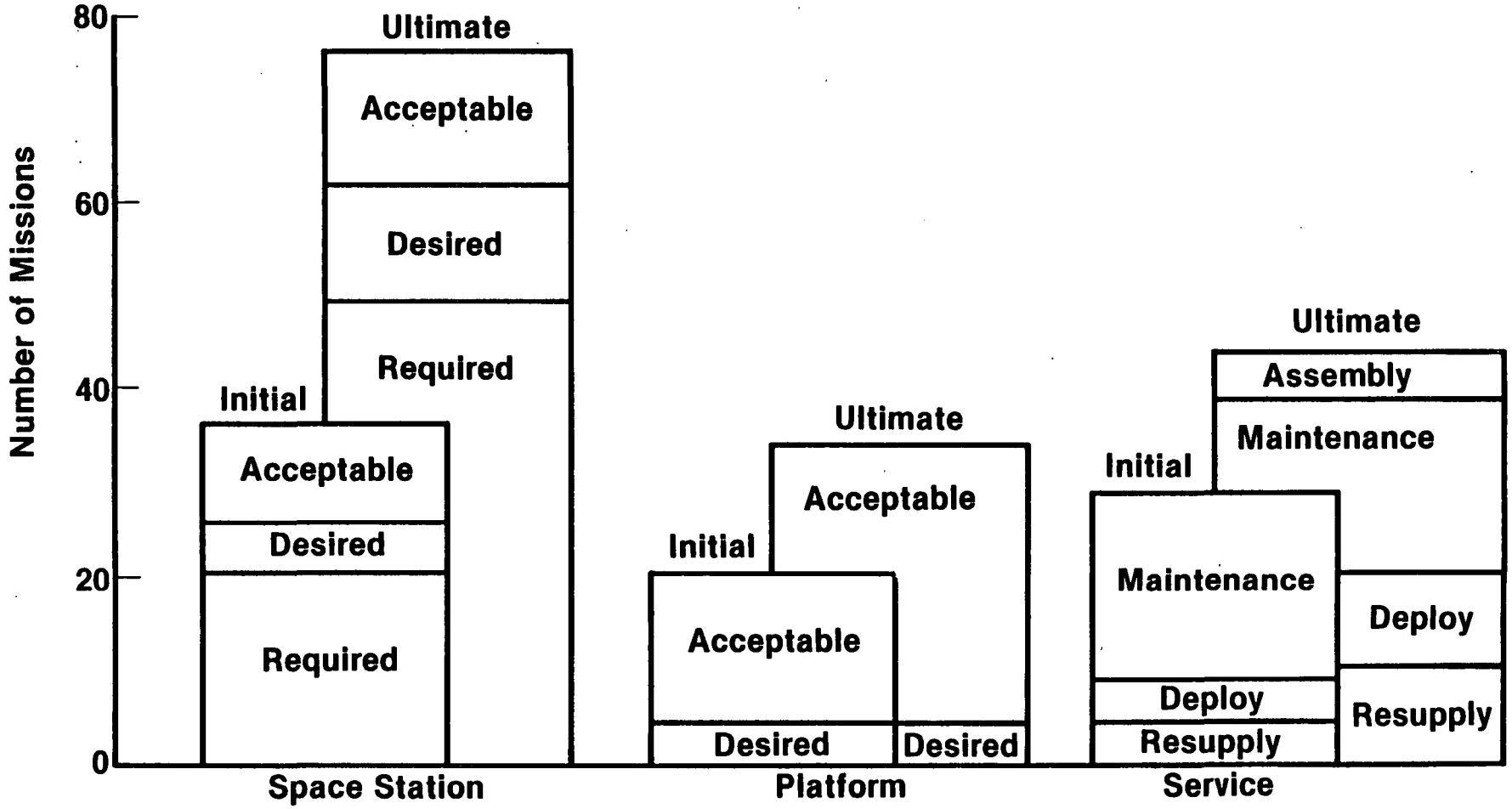
SHUTTLE PERFORMANCE



H28

SPACE STATION
SYSTEM ALLOCATION REQUIREMENTS

VFY000

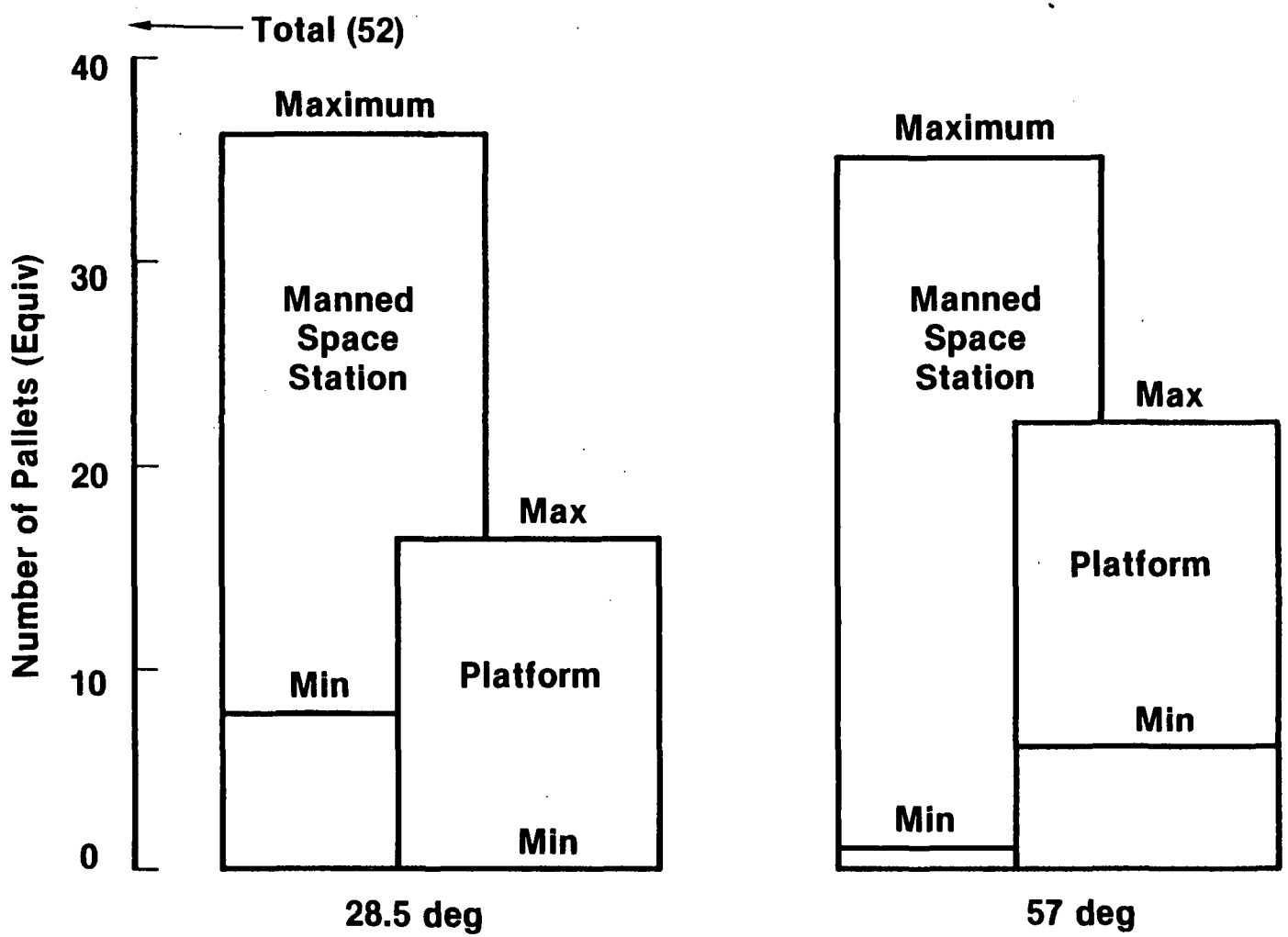


H29

EXTERNAL VOLUME ALLOCATION REQUIREMENTS

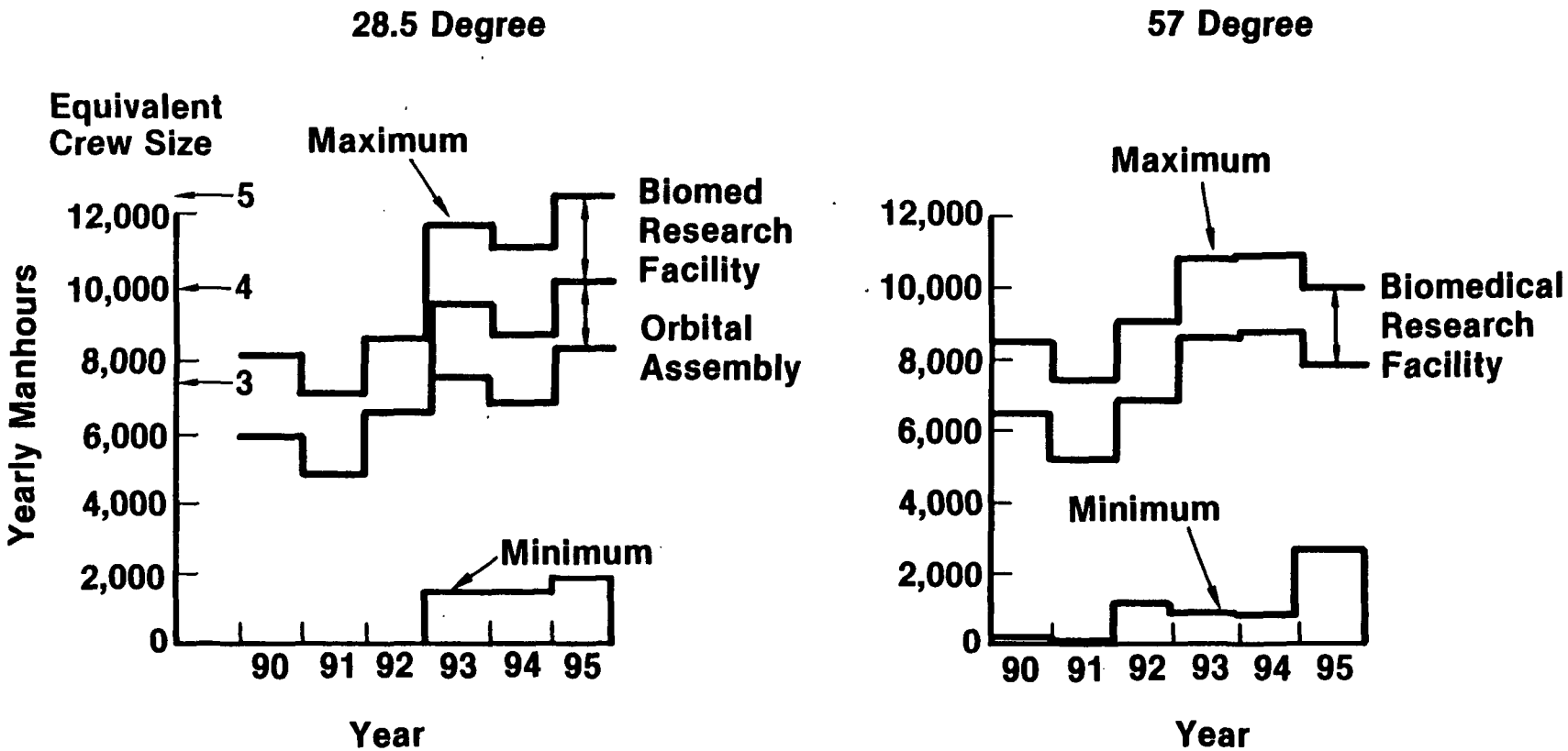
3M Pallets (Equivalent)

VFY147



H30

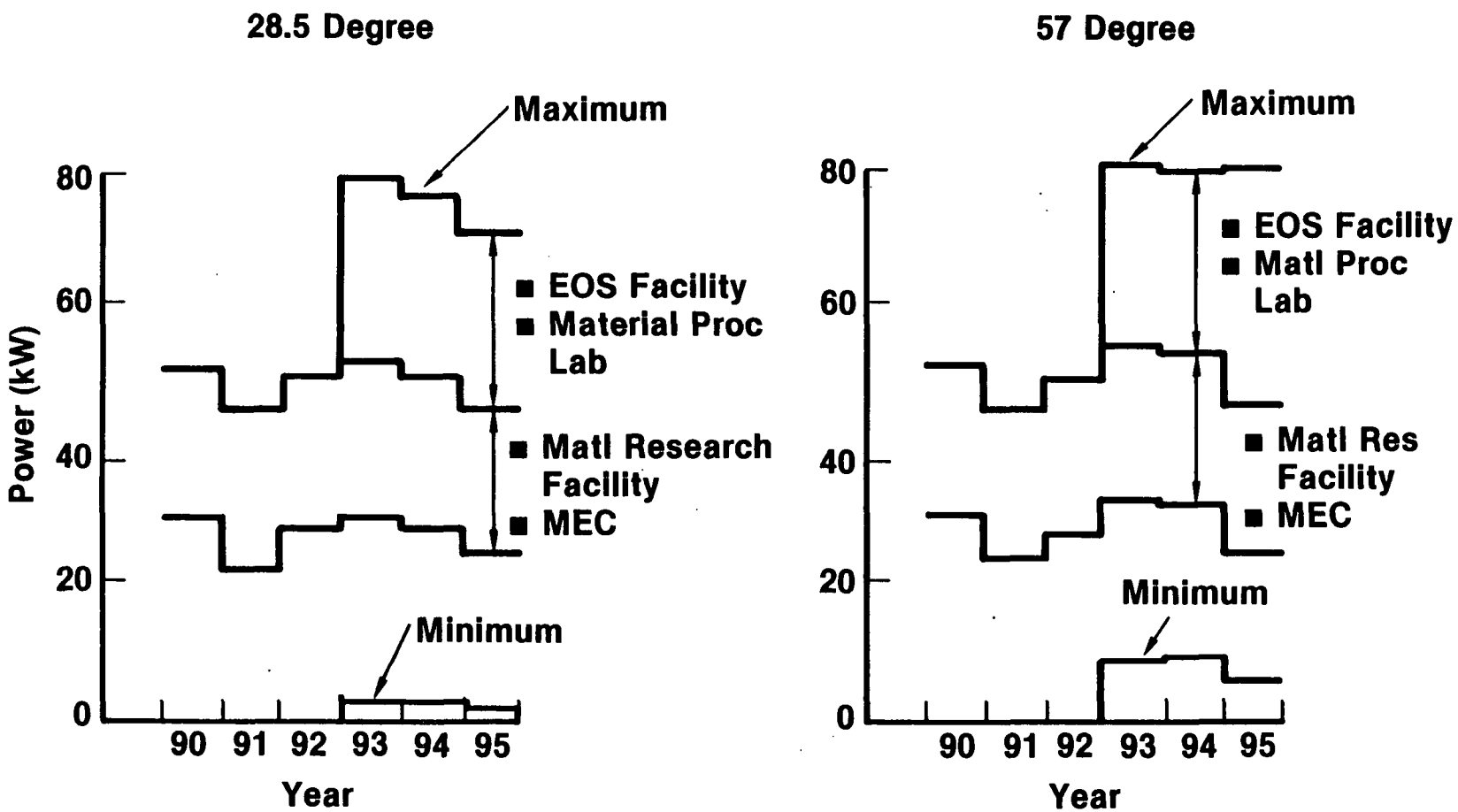
MISSION MANHOUR REQUIREMENTS



H31

MISSION POWER REQUIREMENTS
SPACE STATION INCLINATION ALLOCATION

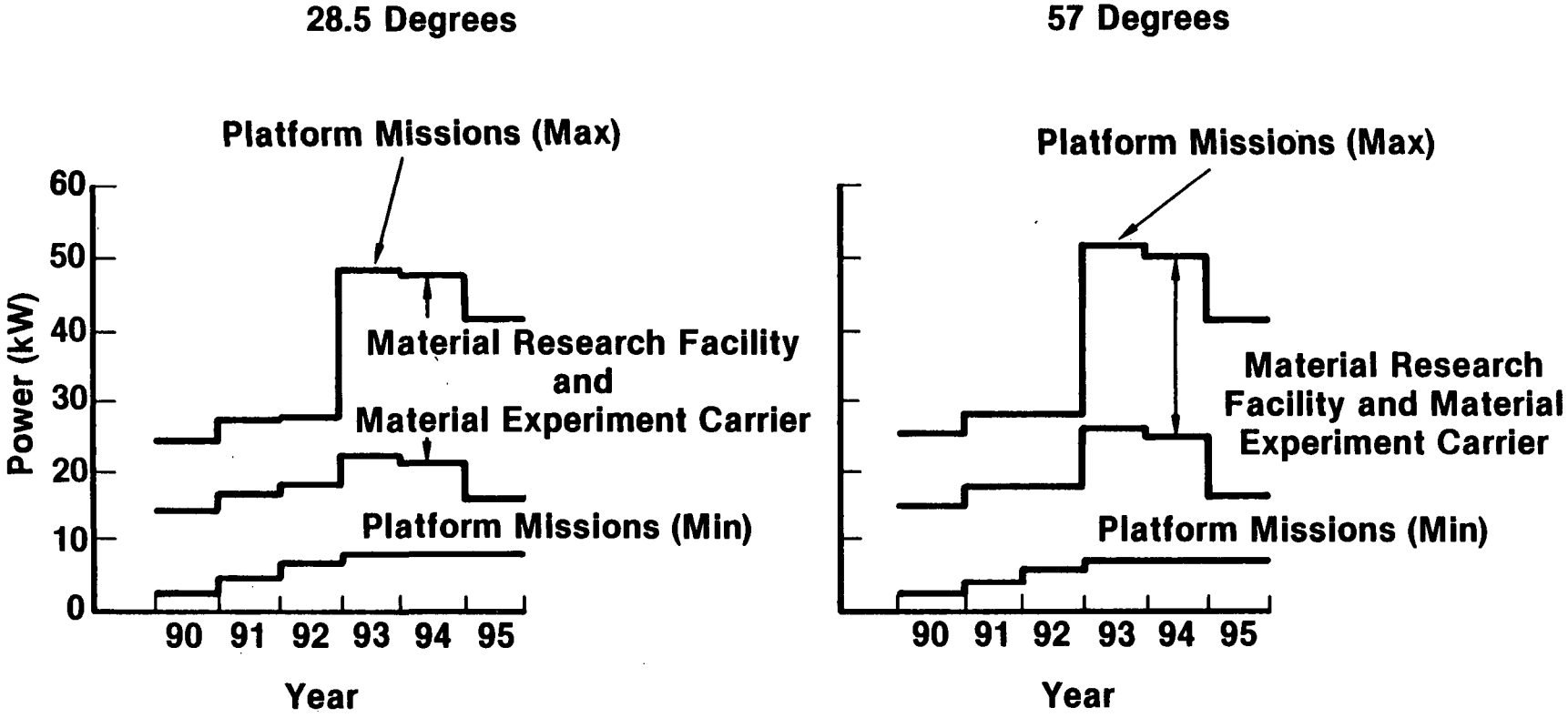
VFY023



H32

MISSION POWER REQUIREMENTS PLATFORM ALLOCATION

VFY083



H33

MISSION REQUIREMENTS ANALYSIS MIDTERM CONCLUSIONS

VFY239

- Manned Space Stations Reequired at 28.5 and 57 Degrees Combined Requirements:
  - Pressurized Modules[(1)]: 8
  - External Pallets[(1)]: Up to 45
  - Crew Size: 4-6
  - Power: 40 to 90 kW
- Unmanned Platforms Desired at 28.5 and 57 Degrees Combined Requirements:
  - Pressurized Modules (Man-Tended): 2
  - External Pallets: Up to 25
  - Power: Up to 48 kW
- STS Growth Needed:
  - TMS: 1990
  - Propellant Depot and Reusable OTV: 1995

[(1)]Equivalent Spacelab 3M Modules or Pallets

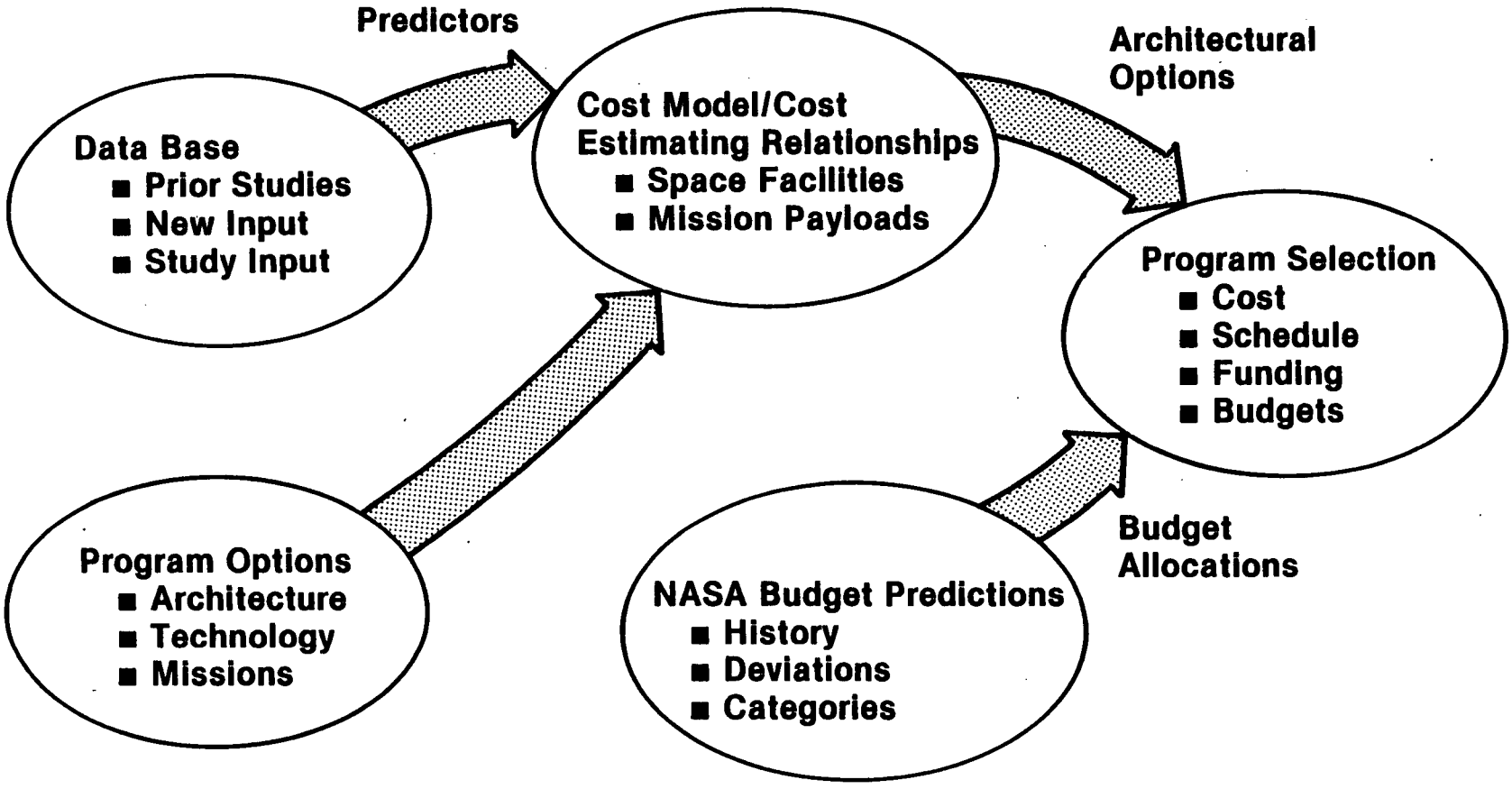
H34

PROGRAMMATICS (TASK 3)

Bob Cowls

J1

MDAC APPROACH — PROGRAMMATICS



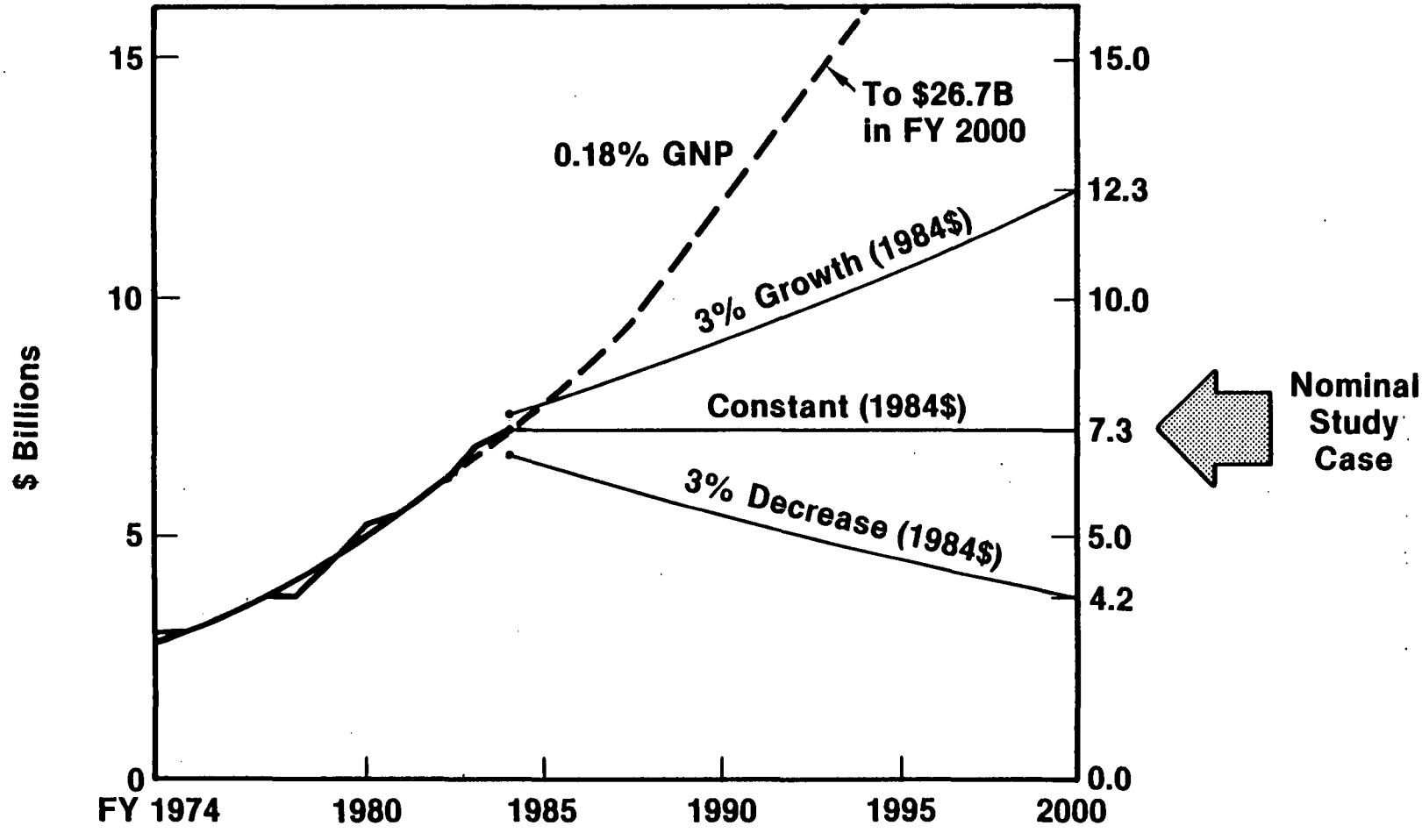
J2

NASA FUNDING PROFILE ASSUMPTIONS

- Continued Correspondence to GNP Growth (0.18% GNP)
- Need Balance Between Orbital Facility and Mission Expenditures (Recognizes Shortfall in Non-STS Areas Over Recent Years)
- No External Funds for Orbital Facilities Development
- Diminishing STS Requirement Produces Budget Wedge Opening

J3

NASA BUDGET FORECAST



J4

VFX897

SPACE STATION PROGRAM BUDGET ALLOCATION ASSUMPTIONS

FUNDING SOURCE	SPACE STATION FACILITIES AND OPERATIONS*	MISSION EQUIPMENTS AND OPERATIONS*					
		SCIENCE AND APP'S MISSIONS	TECHNOLOGY DEVELOPMENT MISSIONS	SPACE OPS** MISSIONS	NATIONAL SECURITY MISSIONS	COMMERICAL MISSIONS	INTER-NATIONAL MISSIONS
NASA							
OSTS	●		○	●			
OSSA		●	○				
OAST			●				
DoD					●		
COMMERCIAL						●	
FOREIGN (BARTER)							●

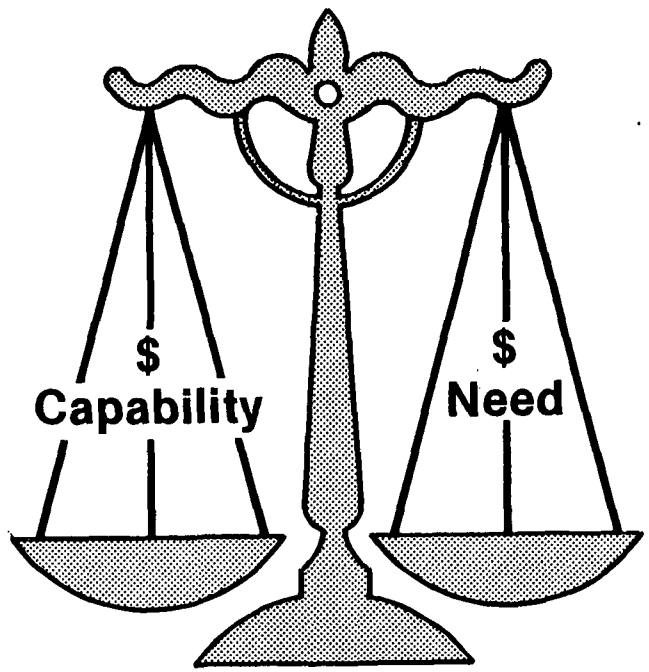
● PRIMARY
○ SECONDARY

*INCLUDES HARDWARE COST (DEVELOPMENT, PRODUCTION) AND OPERATIONAL PHASE ACTIVITIES' COST
**OPERATIONAL MISSION, e.g., SPACECRAFT TRANSFER FROM LEO TO GEO, NOT MISSION OPERATIONAL PHASE ACTIVITIES, VIZ., ACTIVATION, RESUPPLY AND REFURBISHMENT

FUNDING ALLOCATION

Objective: Facility Capability = Mission Needs

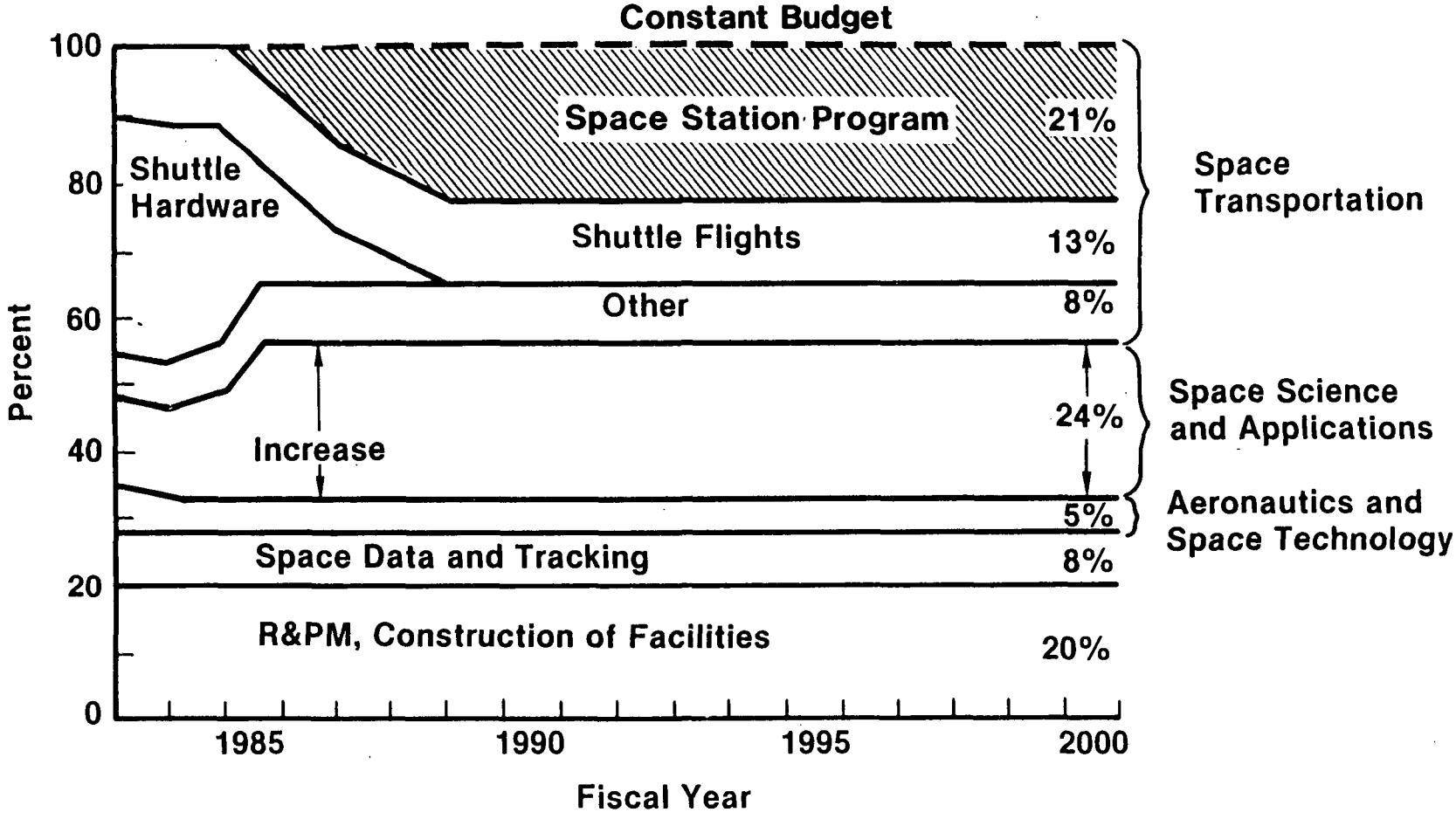
- Orbital Location
- Electrical Power
- Crew Size
- Volume
- Data
- Schedule
- Equipment



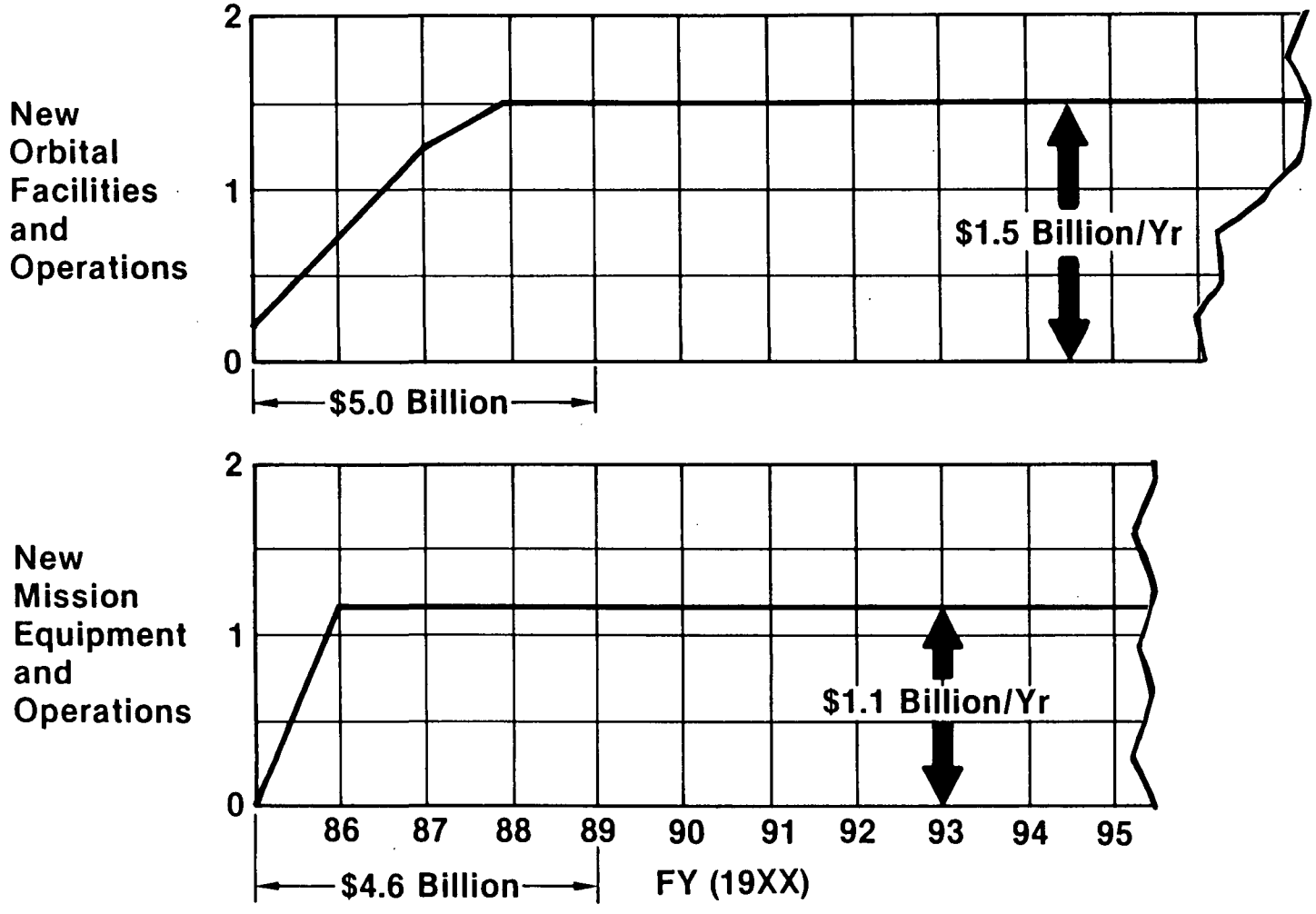
J5

VFY003

NASA BUDGET ALLOCATION ASSUMPTIONS



BUDGET MODEL NOMINAL CASE
(Billion Dollars, 1984)



Notes: (1) Science and Applications Budget Increased 60% Above 1983
(2) Shuttle Flights Budgeted at $0.9 Billion/Yr, Are Excluded
(3) All NASA Funds; No Commercial, DoD or Foreign Funds

J7

PROGRAMMATICS SUMMARY

- Funds for Space Station Program Are Available Due to Diminishing Shuttle Hardware Costs
- Funds for Fifth Orbiter Available
- Balance Between Mission Needs and Facility Capability Is Necessary

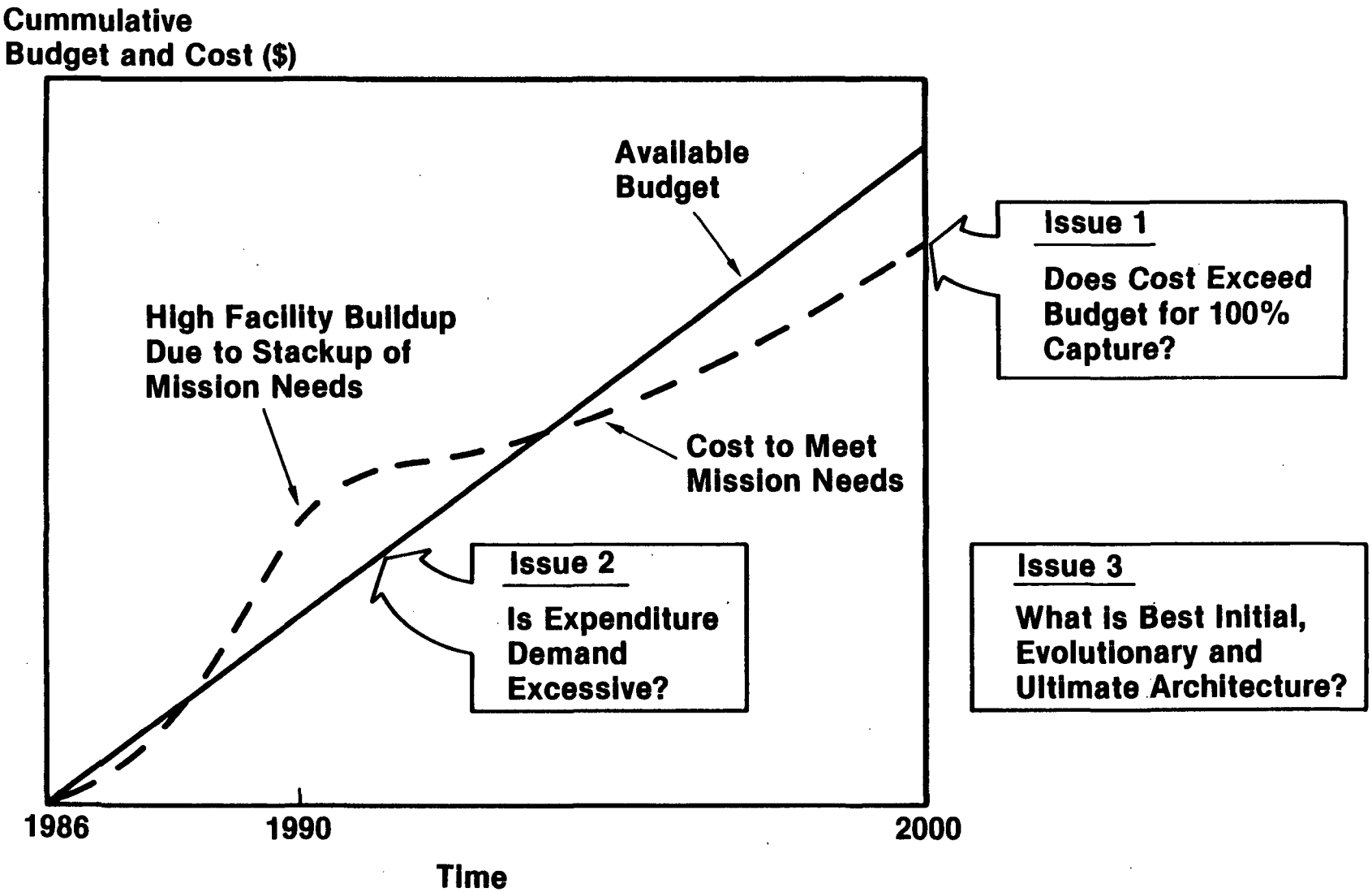
J8

MISSION IMPLEMENTATION (TASK 2)

Bill Nelson

TASK 2
MISSION IMPLEMENTATION CONCEPTS

VFY027



K1

ARCHITECTURAL GOALS

- Maximize Mission Capture
  - — Total Number
  - — Number of Categories
- Provide Flexible Accommodations
  - — Orbit Locations
  - — Facility Types
- Maximize Cost Effectiveness
  - — Cluster Facilities Preferred
  - — Locate at Shuttle Traffic Lanes (Comanifesting)
  - — Maximize Mission Capture per Unit Cost

K2

MISSION LOCATION AND FACILITY TYPE REQUIREMENTS

VFY008

Inclination (deg)	Facility Type											
	Manned			Either			Either			Unmanned		
28	17					4	4					1
28-57		4			2			2			4	
28-90			4			0			0			1
28-98			17	5					5	1		
57	4				3		3				0	
57-90		1			7			7			0	
57-98			2	3					3	1		
90		0			1			1			0	
90-98			1	0					0	1		
98			3	1					1	0		

Number of Missions Requiring Manned Facility at 57 Degree Inclination

K3

MISSION CAPTURE FOR SPACE STATION AT 57° INCLINATION

VFY009

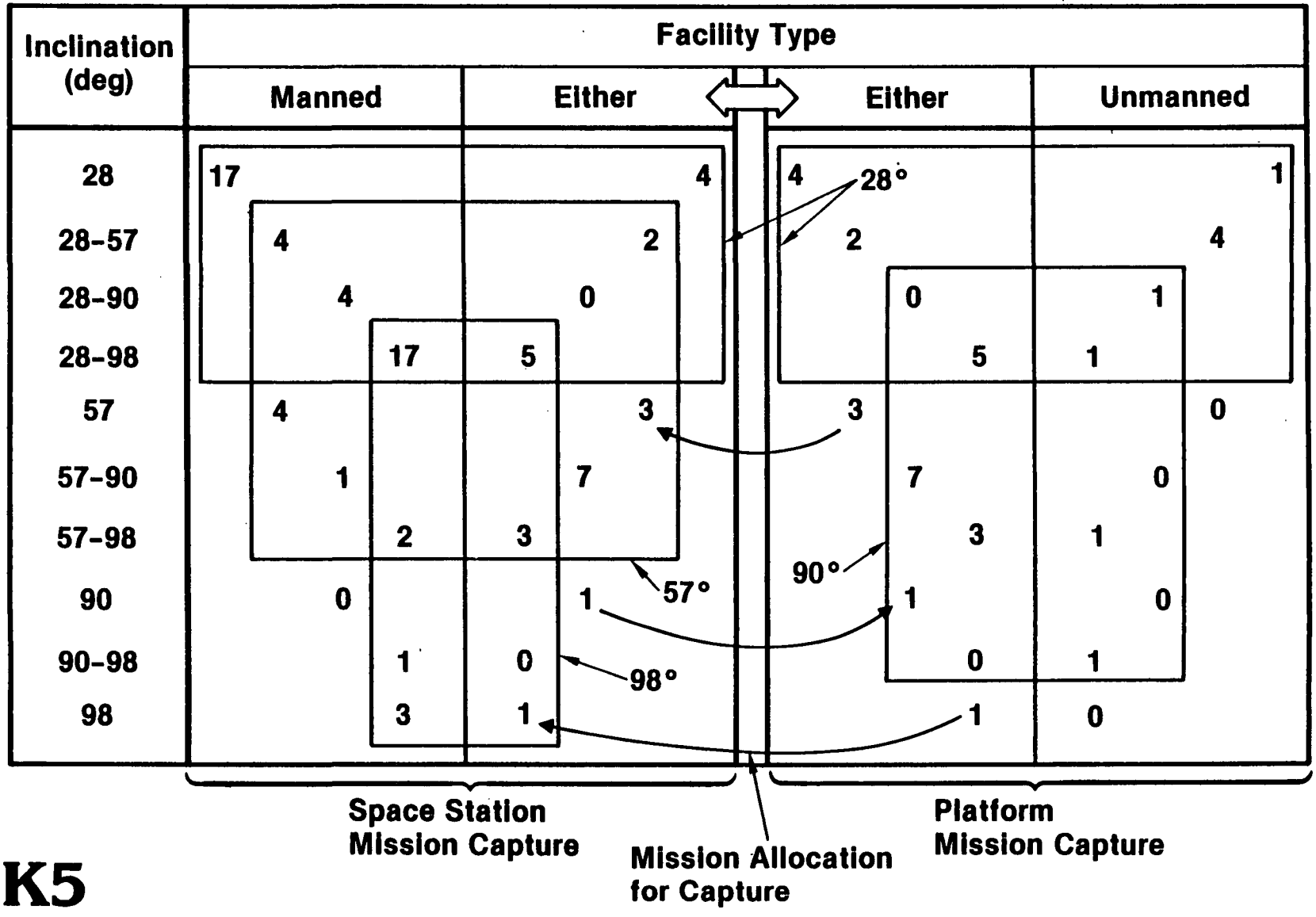
Inclination (deg)	Facility Type											
	Manned			Either			Either			Unmanned		
28	17					4	4					1
28-57		4			2			2			4	
28-90			4			0			0			1
28-98				17	5					5	1	
57		4				3		3				0
57-90			1			7			7			0
57-98				2	3					3	1	
90			0			1			1			0
90-98				1	0					0	1	
98				3	1					1	0	

Mission Capture for Space Station at 57 Degree Inclination

K4

FACILITY NUMBER AND LOCATION FOR 100% MISSION CAPTURE

VFY010

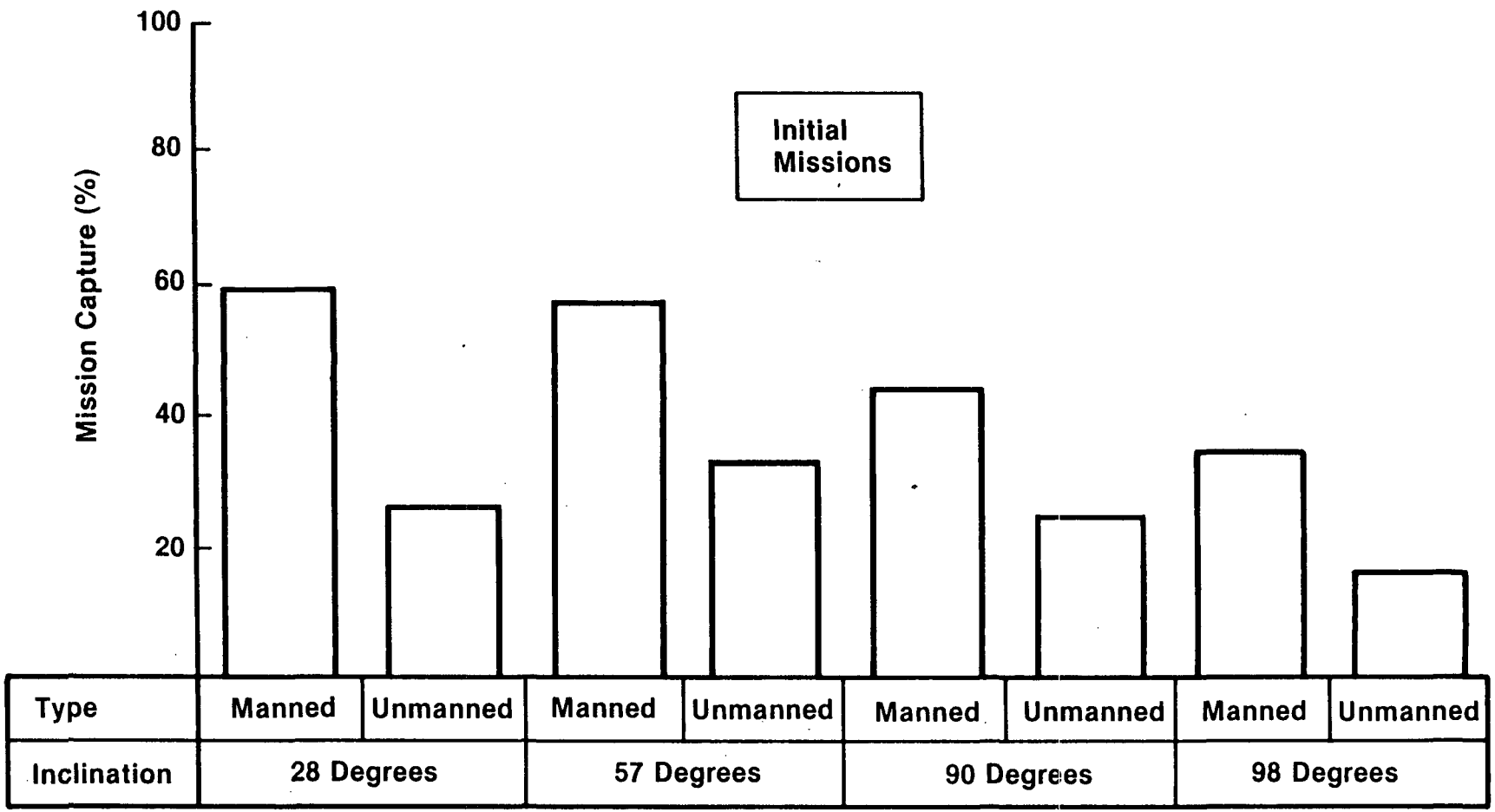


K5

SINGLE FACILITY MISSION CAPTURE

VFY167

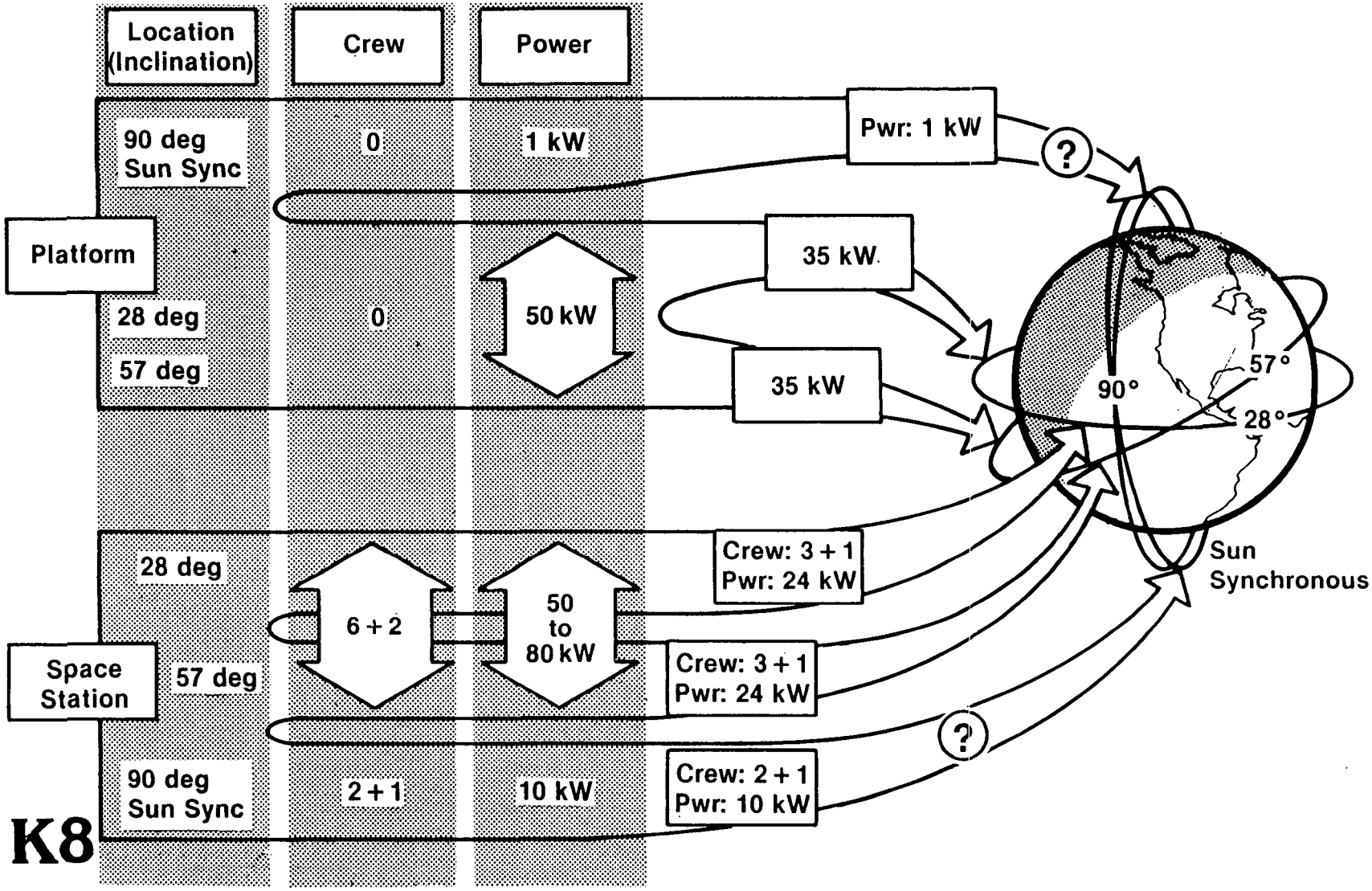
(Shows Maximum Mission % Capture by Any Single Facility)



K6

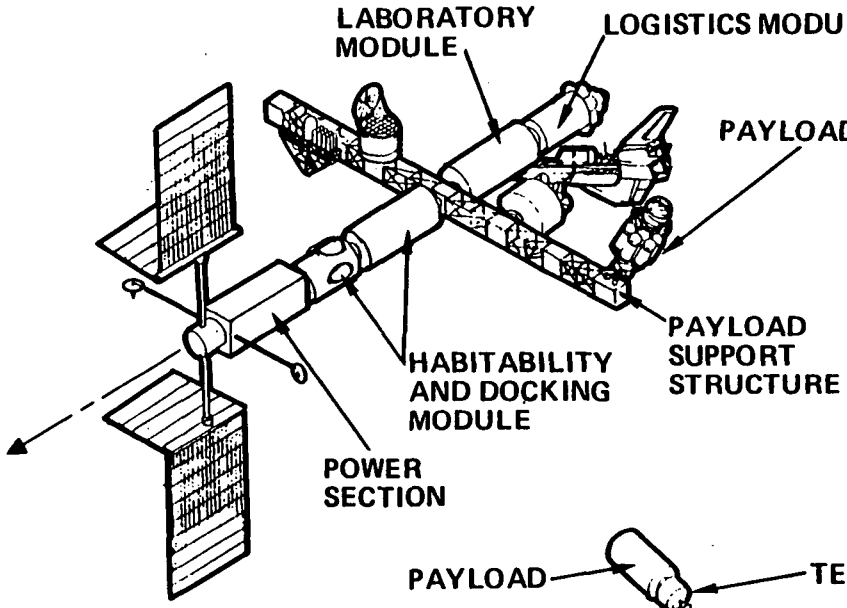
ALLOCATION OF FACILITY REQUIREMENTS ULTIMATE CAPABILITY

VFY135



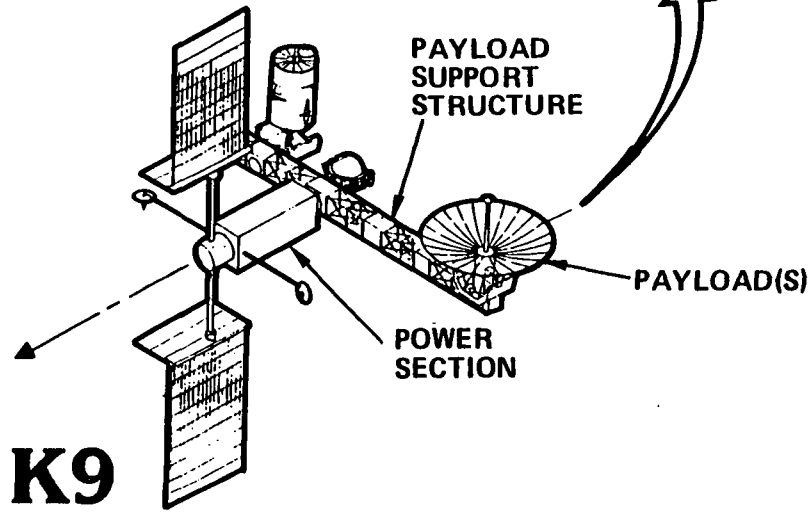
INITIAL CAPABILITY SPACE STATION FACILITY

VFY065



Manned Space Station

- Crew — 4
- Payload Power — 24 kW
- Total Power — 37 kW
- Data — 120 Mbps
- Payload Complement — 10



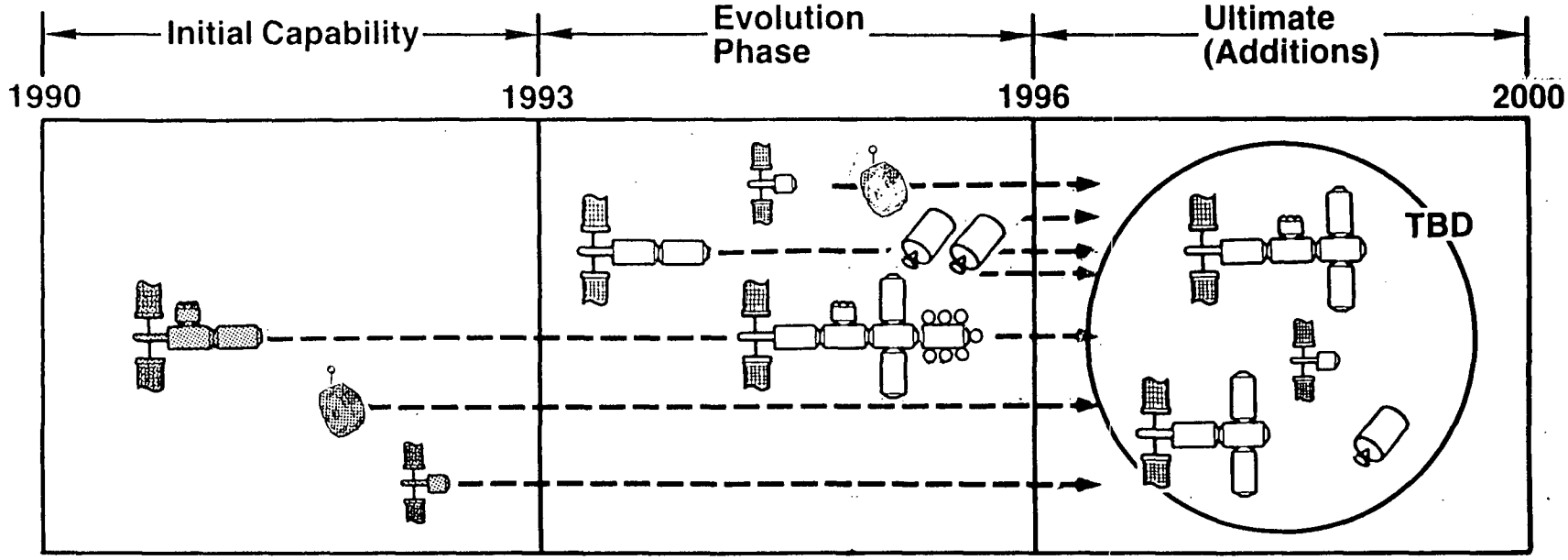
Platform

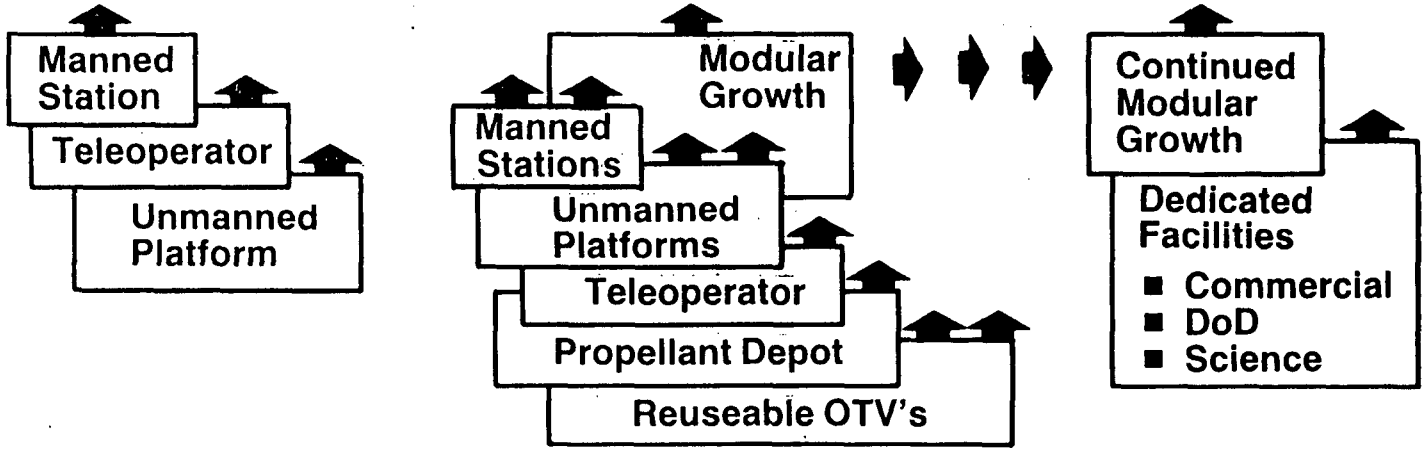
- Payload Power — 35 kW
- Total Power — 38 kW
- Data — 120 Mbps
- Payload Complement — 10

K9

VFY254

CAPABILITY GROWTH OPTIONS



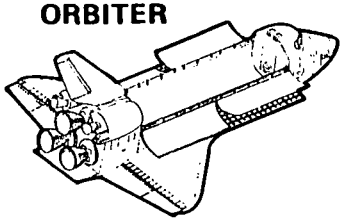


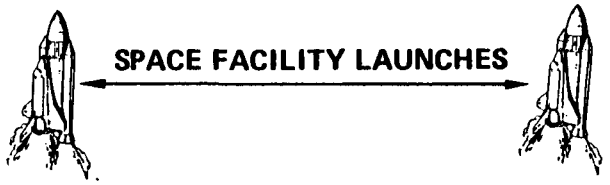
STS ELEMENTS FOR SPACE STATION PROGRAM

VFY064

1990	1991	1992	1993	1994	1995	1996	1997	1998	1999

ORBITER





SPACE FACILITY LAUNCHES

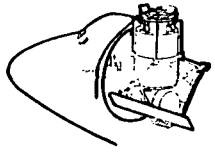
LOGISTICS/PAYLOAD

ORBITER RMS

SPACE FACILITY ASSEMBLY

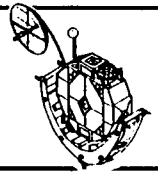
BERTHING OPERATIONS

DOCKING MODULE



BERTHING OPERATIONS (CREW AND LOGISTICS TRANSFER)

TMS



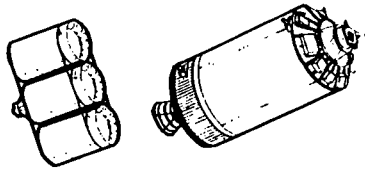
SPACE FACILITY ASSEMBLY/PLACEMENT

PAYLOAD DEPLOYMENT/RETRIEVAL

MMU

PAYLOAD SERVICING

REUSABLE OTB



PAYLOAD DEPLOYMENT/RETRIEVAL

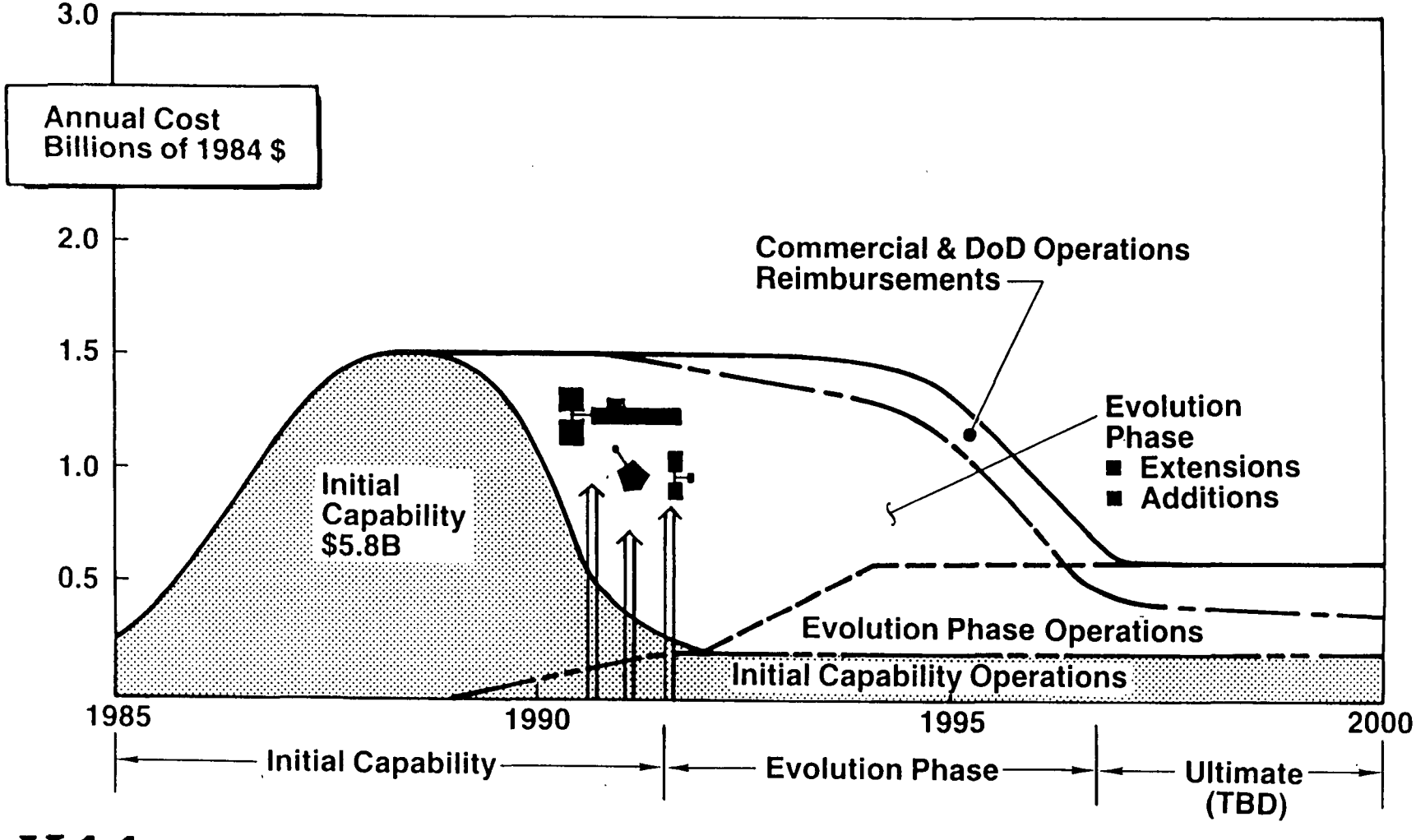
DEPOT PROVISIONS

K11

SAMPLE PROGRAM COSTS

100% MISSION CAPTURE

VFY269



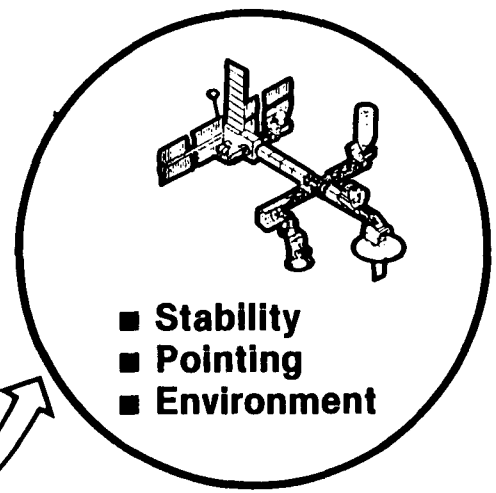
K11

SPACE STATION SYSTEM GROWTH BASED ON SPECIALTY NEEDS

VFY066

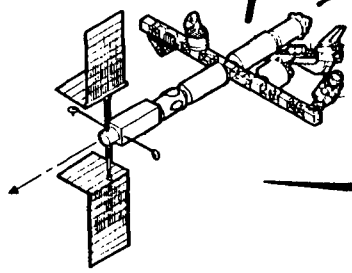
- Proprietary
- Ample Resources
- Disturbance Free
- Private Funds

Commercial



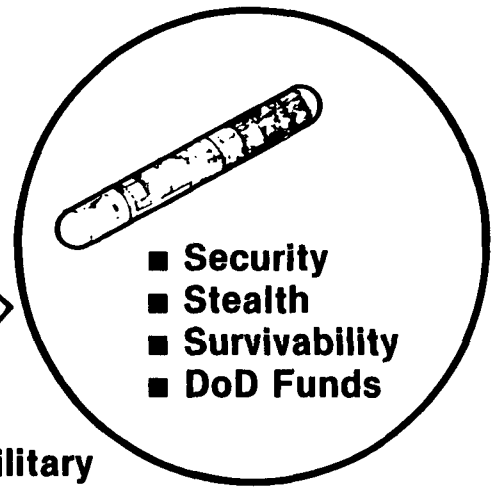
- Stability
- Pointing
- Environment

Science and Applications



NASA Facility

- Proof of Principle
- Development
- Procedures
- Hardware



- Security
- Stealth
- Survivability
- DoD Funds

Military

K13

CONCLUSIONS
MISSION IMPLEMENTATION CONCEPTS

- 100 Percent Mission Capture Possible
  - — Within Total Budget Limits
  - — Space Stations/Platforms/Transportation
- Buildup Constraints
  - — Rate of Budget Availabililty
  - — Production Rates
- Initial Capability in 1990 - 1991

K13

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY-HUNTINGTON BEACH
5301 Bolsa Avenue, Huntington Beach, California 92647 (714) 896-3311